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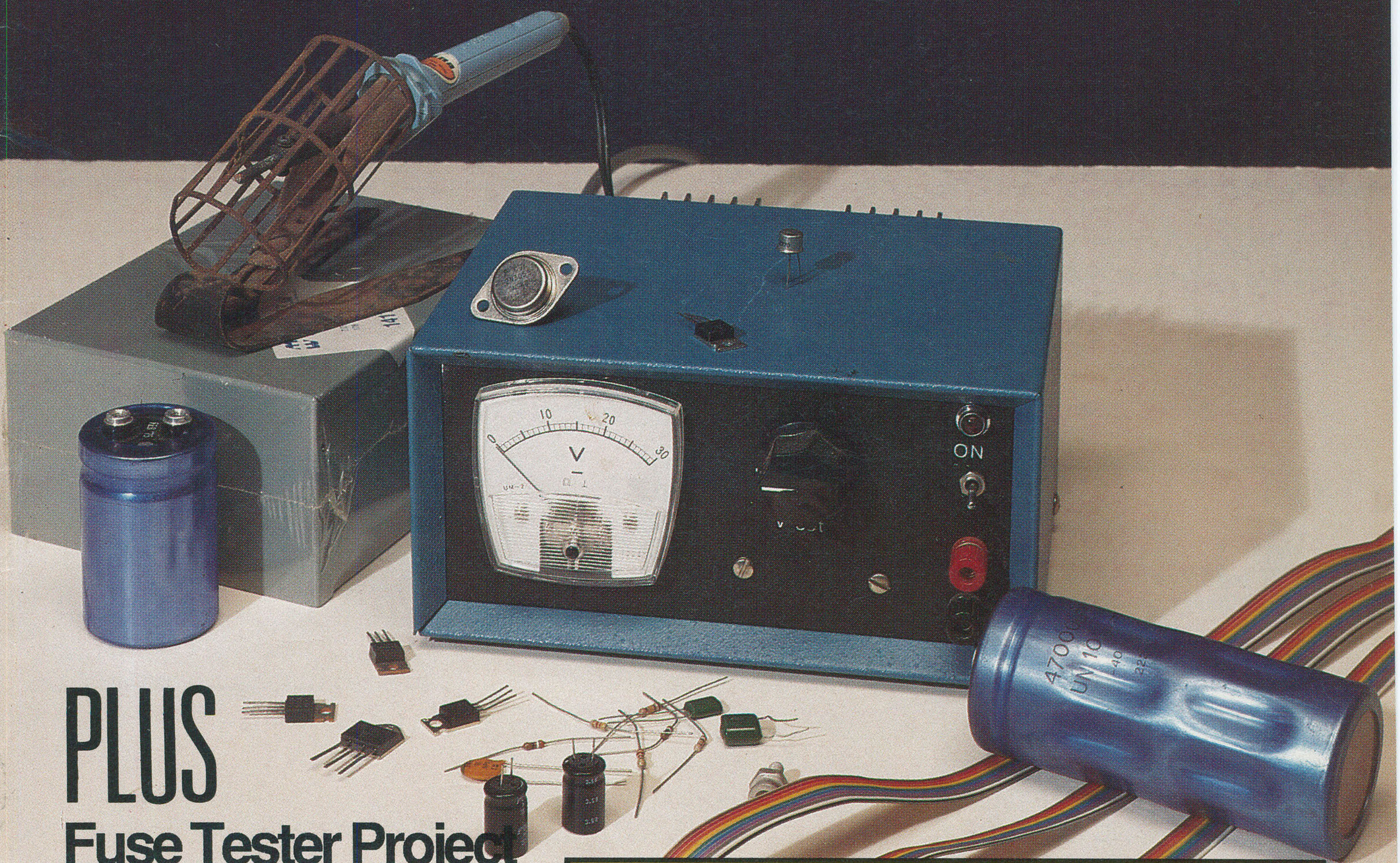

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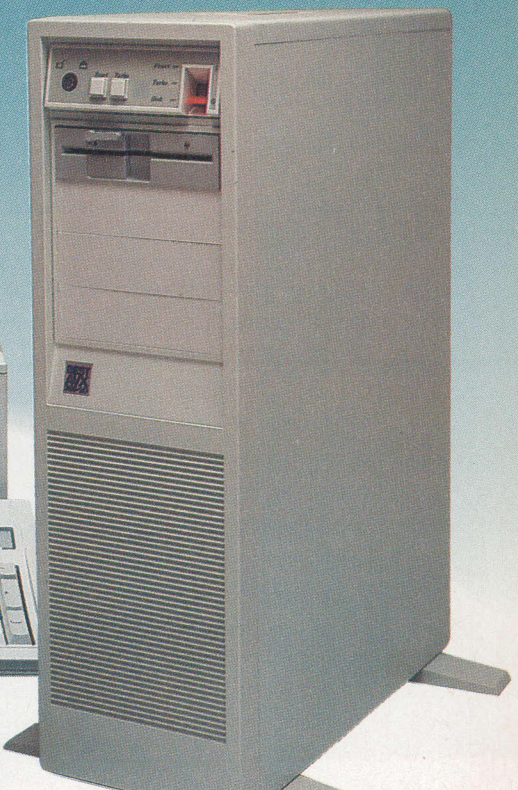

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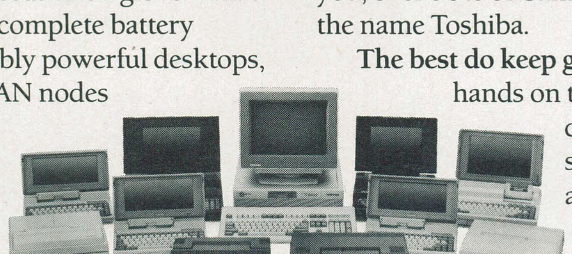

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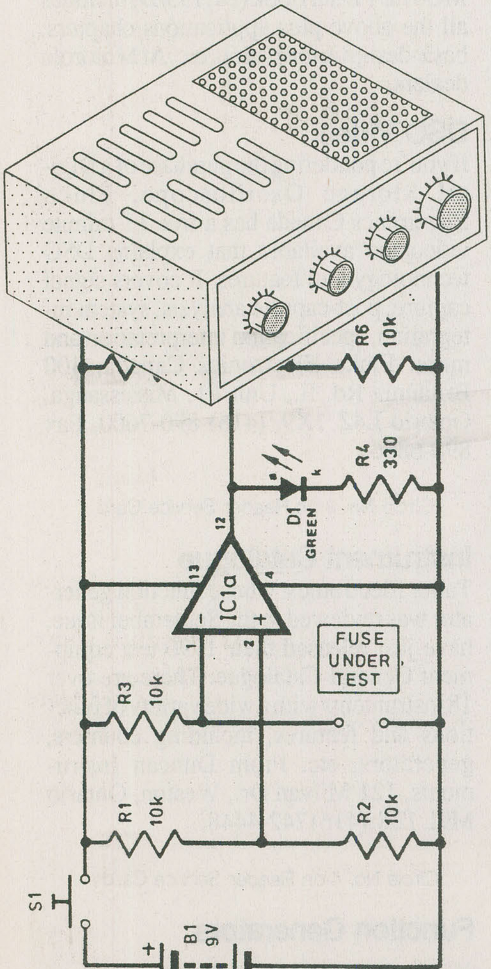

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Instrument Catalogue

Tabor Electronics, whose function generator was reviewed in the September issue, have just released their 1990 test equipment General Catalogue. There are over 18 instruments with a wide variety of functions and features, including counters, generators, etc. From Duncan Instruments, 121 Milvan Dr., Weston, Ontario M9L 1Z8, (416) 742-4448.

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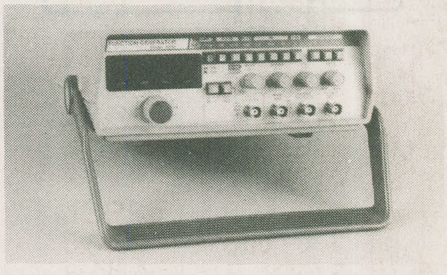
Function Generators



Brunelle Instruments announces the latest additions to their Commander Series, the Models 3020 and 3030 function generators. The 3020 features sine, square, triangle, pulse and ramp waveforms from 0.2Hz to 2MHz in seven ranges. The Model 3030 adds a frequency counter. Brunelle Instruments, 73-6th Range South, St-Eleie-d'Orford, Quebec J0B 2S0, (819) 563-9096, Fax 569-1408.

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New Name and Catalog

Effective September 1, Circuit Test Electronics is the new name for one of Canada's original test equipment importers, H.W. Cowan Canada Ltd. Just released is their new Circuit Test Catalogue, featuring test gear, power supplies, and electronic teaching aids. Brands featured include Electronic Kits International, Emco, Eico, Elenco, Kappa-Viz Test Equipment, Metex, Pegasus, Circuit Test, Power All, Circuit Works, etc. The Electronic Kits International Robot and Microprocessor Course is of particular interest, allowing instructros a wide degree of latitude: the Model 567 WRJ is for middle and junior high school, while the 567 WRPX lets high schools and tech schools offer machine language programming and robot control. Circuit Test Electronics, 2113 West 4th Ave., Vancouver, BC V6K 1N7, (604) 738-2944, Fax 738-3002.

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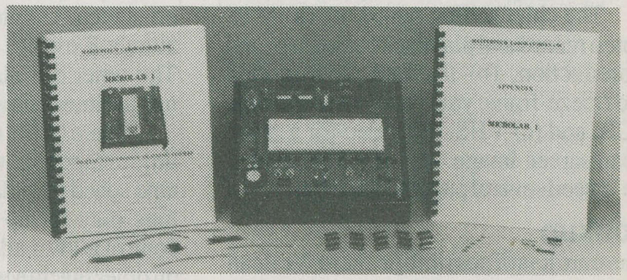

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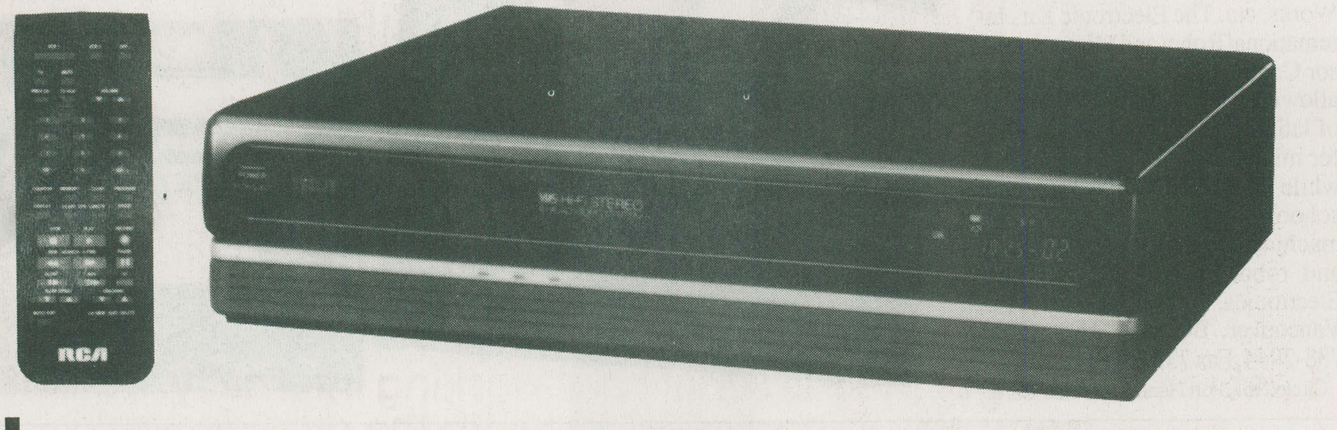

Now that VCRs are everywhere, manufacturers are going beyond mere record/playback devices and are adding lots more features. RCA's new VR620 VHS Hi-Fi unit has so many that it takes a 54-page manual to explain them all.

The chief selling points are (a) MTS stereo record and playback for ideal sound reproduction, (b) the best slow-motion and freeze-frame you've seen in any home VCR, and (c) VHS-HQ video for a crisp, clean screen image. As for all the others, we'd need several pages to list them.

Hookup

There are lots of possibilities here. You can connect any cable or antenna system to the 155-channel tuner (99 unscrambled cable channels). The TV can be fed from standard A/V jacks, or from an included RF cable. If you don't have a stereo TV, the left and right channel outputs can be plugged into the auxiliary inputs of your stereo sound system.

There are complete instructions for connecting cable decoders into the system, though you may have to purchase a splitter box for the most convenient operation.

The Remote

The infrared remote control has 46 buttons on it; despite this, learning the functions isn't too difficult. You can switch between the VCR and the TV, allowing you to watch one program while taping another, or you can switch to a second VCR (for those who take taping seriously).

Besides the usual channel selection controls, you can set up your favorite channels by means of menus that appear on-screen. The clock, again set by a menu, allows 8-event/1-year recording timing. The timer can also be quickly set in 30-minute intervals with the Express feature.

Some of the other buttons control the time or tape counter on-screen display, the tape speed (standard, long play and extra-long play for up to 6 hours). A tracking control allows adjustment for tapes made on other machines that may not be perfectly aligned.

Tape Motion

If you had to choose just one thing that distinguishes the VR620 from other VCRs, it would probably be the superb tape motion controls. The 4-head double azimuth system produces perfect freeze-frame without white noise bars, and the slow-motion is the best you'll see outside of professional studio gear. This should be an excellent learning aid for sports techniques (or taking movie special effects apart to see how they did it).

There's a button for frame-at-a-time advancing, and another for double-speed forward. And, of course, the usual rewind-fast forward shuttle search.

Sound

The quality stereo record/playback is good enough that you no longer have to worry about the usual degrading of sound by the TV system; what goes in, comes out. In addition, there's a switch on the VCR front panel that lets you listen or record the Second Audio Program (SAP), a normally unnoticed audio channel that's carried by MTS stereo and decoded by the VR620. This channel can be used for a second language or program comments.

Sadly, the remote control sound buttons work only with RCA remote-equipped televisions. You'll still need your TV's remote for controlling the audio. It does seem odd that a sound modulator wasn't added; it's particularly needed when you pipe the sound through your stereo system, especially if it isn't near the TV.

And so...

And so it's a good thing that the manual is superbly organized, because there are lots of features to learn. Of course, even if you don't use any of them, you're going to have some of the best audio and video possible from normal VHS, plus that fabulous slo-mo. The list price of the VR620HF is $899, but dealers usually discount well below this. ■

PC Hardware Interfacing Part 10

Last month we got the PC serial card working internally, but left it without any way to communicate with the outside world. This time around we'll have a look at finishing up the hardware involved in adding this useful facility to the design.

STEVE RIMMER

Despite the obvious importance of doing so, making our emerging serial card actually able to communicate with external devices is pretty simple. There's no complex binary math to concern ourselves with, and really very little hardware. Of course, the hardware is a bit obtuse, but this is to be expected when one is dealing with a fifty year old standard.

The only tricky thing about serial communications is that it's designed to work with hardware which really predates microcomputers by quite a long while. Whereas everything inside a computer uses predictable logic levels and timing, serial data is a world unto itself. Regrettably, it's something which must be endured, having become entrenched in our universe.

Bilevel Tuba Solo

The first serial devices were teletypes, which puts the origin of this form of communication back several decades. Early teletypes were wholly mechanical, with lots of solenoids and relays and numerous other things too arcane and horrible to contemplate. They did use these devices to synthesize a crude form of electronic logic, however. A teletype took keyboard input, translated it to serial data, sent said data over wires and ultimately turned it into hard copy at the far end of the line.

Big, clunky solenoids that can drive an old style print mechanism do not run cheerfully on five volts. For various reasons, the logic levels of those old teletypes, and hence of our modern serial communications, were such that a positive voltage was considered to be one and a negative voltage zero. Zero volts... and, in fact, anything within several volts of it... was and is undefined.

The original range was forty-eight volts either side of zero. Contemporary serial devices use twelve volts. However, because of the way this system is structured, anything beyond three volts positive is considered to be a logic level of one, and anything beyond three volts negative is a logic level of zero. As such, some devices use plus and minus five volts and get away with it.

The advantage of this bipolar system is actually fairly apparent. Devices which use differing voltage levels can communicate without specialized line drivers. In addition, bipolar logic levels can live with a great deal more voltage loss because of line resistance before they start losing data. This isn't much of a problem now unless you'll be driving serial data over fifty feel of cable, by it impressed the teletype guys to no small end way back in the middle ages.

The only real problem facing the hardware we're about to look at, then, is converting the PC's TTL logic levels to these rather more obtuse ones and back again. As we'll see, there are special parts to do this for us. The 1488 and 1489 chips... as are found in just about every microcomputer serial port design... conveniently change TTL logic levels to serial port logic levels and back again.

The actual serial lines to be interfaced are something of a wonder as well, once again dating back into the mists of prehistory. In theory, serial data can be managed using only three lines, one of which is ground. Labeled TXD and RXD on our schematic, these things send and receive serial information respectively. As long as the hardware at the other end of the serial

PC Hardware Interfacing, Part 10

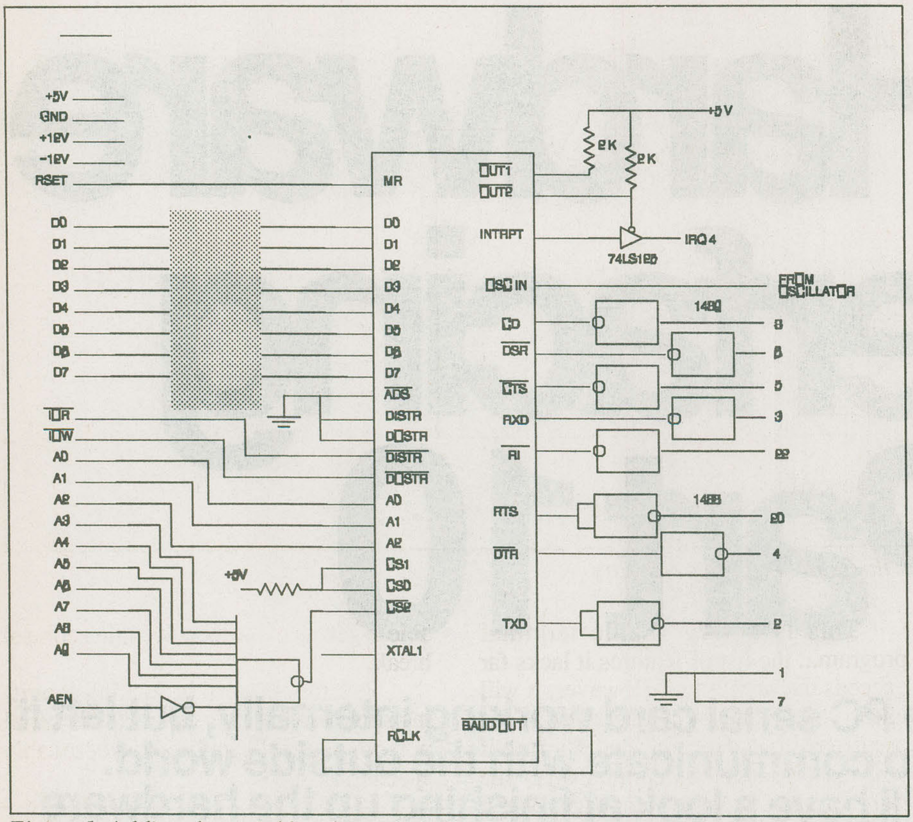

Figure 1. Adding the serial hardware interface. Numbers to the right of the drawing are RS-232C Interface pins.

link is up for dealing with the data at the rate our computer wants to send it, all will be well.

In practice, this *is* usually the case with contemporary computers, but it didn't used to be. As such, serial connections also include some "handshaking" signals which allow the sending computer to ask the receiving computer whether it's free to receive a byte and the receiving computer to answer. The DTR line tells the computer on the other end that the local machine can accept a byte of serial information. It means "data terminal ready". The CTS line inquires as to the status of the remote computer. It means "clear to send".

There's also a "carrier detect" line... marked CD on the schematic... which may or may not be required, depending upon your application. This tells the host computer whether there is a modem carrier present at the serial port's attached device... which only means something if the attached device is, in fact, a modem.

The ring indicator line... RI on the drawing... can be used to tell the program driving the serial port that the telephone is ringing. The 8250 can be programmed to generate an interrupt when this line changes state, so it's quite possible to write software which pops up out of the background only when someone calls in. We'll look at this sort of driver a bit later on.

The serial port's oscillator is a simple crystal and two inverters, a pretty standard way to handle one of these things. The frequency of the crystal is chosen to allow the internal frequency divider of the 8250 to generate common standard baud rates. This is the same frequency that the actual ports in a PC uses, as well as most other implementations of this chip.

I should point out that this schematic is not complete... I've deliberately omitted the power connections and such to the chips in order to keep the wiring as clear and easily understood as possible. If you actually elect to build this card as it stands, you'll want to fill in these details. In most cases, though, you will probably want to build variations on it. Basic serial ports for the PC are as common as politicians at election time and just as easy to find.

Testing the Serial Port

Exercising the card to test *all* its facilities actually requires quite a bit of sophisticated software and hardware. However, if we allow that the actual chip is probably performing properly, we can check the basic circuitry with a few simple code fragments. To make sure that the fundamental communications facilities of the serial port are actually working, let's write a very basic terminal program.

To begin with, you don't actually need a second terminal or computer to test a serial port. Because an RS232 port has separate incoming and outgoing data lines, it can send and receive data at the same time. As such, it's quite easy to test the beast by simply connecting the TXD and RXD lines together... that's pins two and three... and sending data out. If the data comes back, the card's working.

If you have a terminal or modem program for your PC... such as Telix, Q-Modem, CrossTalk and so on... you can test the serial port with this. However, as we'll be looking at writing proper drivers for the port beginning next month, you might feel like getting your fingers dirty with a bit of assembly language now.

In order to talk to the board at its most primitive level, we must initialize the card... set its baud rate and other communications parameters... and then create a loop in which our test program polls for keyboard and serial data. If it finds a character waiting at the keyboard, it sends the character to the serial port. If it finds a character at the serial port, it sends the character to the screen.

There are a few holes in this simple model which make it unsuitable for use as a real terminal... things like interrupts, character translation and a few other things enter into it... but it's good enough for testing.

All of the following assumes that you have jumpered pins two and three of the card. I should point out that this test will work on any serial port configured as COM1 on a PC... you can use a known serial port to test the test program if you're not sure of it.

To begin with, we must set the baud rate. We'll use three hundred baud here, although the card will support up to fifty-six kilobaud if you've used reasonably good parts.

```
MOVDX,3FBH
MOVAL,80H
OUTDX,AL;OPENDLAB

MOVDX,3F8H
MOVAL,80H
OUTDX,AL;SETLOWORDERBAUD

MOVDX,3F9H
MOVAL,01H
```

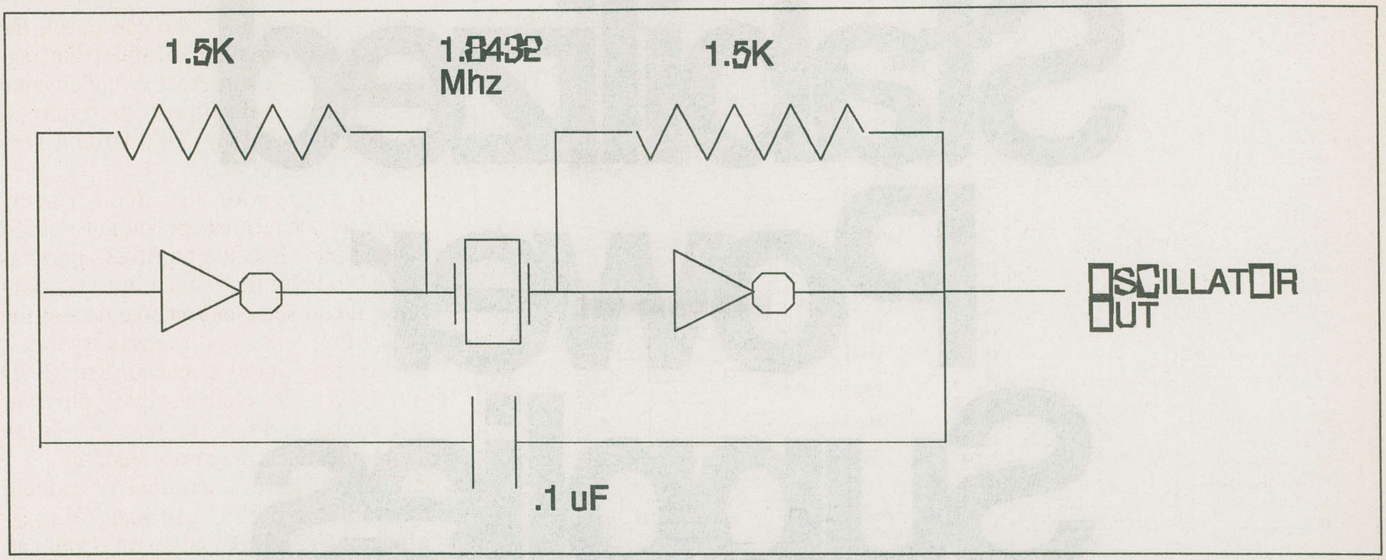

Figure 2. A crystal controlled oscillator to drive the 825D serial port circuitry.

```
OUTDX,AL;SETHIGHORDERBAUD

MOVDX,3FBH
MOVAL,1AH
OUTDX,AL;SETCFW
```

We'll get into how this works in more detail later on.

Next, we have to create the basic terminal loop. This is what it looks like.

```
T_LOOP:MOVDX,3FDH
INAL,DX;GETTHERXPORTSTATUS
TESTAL,1;ISBITSETFORBYTEWAIT-
ING?
JZT_KEY;IFNOT,CHECKTHE
KEYBOARD

MOVDX,3F8H
INAL,DX;IFSO,GETTHEBYTEFROM
PORT

ANDAL,7FH;MASKOFFANYGAR-
BAGE

MOVDL,AL
MOVAH,2
INT21H;PRINTTHECHARACTER

T_KEY:MOVAH,1
INT16H;ISTHEREAKEYWAITING?
JZT_LOOP;IFNOT,CHECKTHEPORT
AGAIN

MOVAH,0
INT16H;IFSO,FETCHIT

MOVDX,3F8H
OUTDX,AL;SENDITOUT

JMPT_LOOP;GOLOOPAGAIN...AND
AGAIN...
```

This is a very simple terminal program... the list of features it lacks far exceeds the ones it has. However, it will allow you to check out a serial port. It's pretty easy to understand what it's up to if you read through the comments to the right of the assembly language. We'll have a proper look at what all the numbers mean starting next month.

You might have noticed that there's no obvious way to get out of this program. A proper terminal would probably provide an escape clause. In this case, being a test program, you can just hit control break to abort the look. It's inelegant, to be sure.

By the way, if you've been following the C language serial which has also been in this magazine over the past few months, you might be interested in seeing how this would be done in C. The following C program would result in much the same actual executing code when it was compiled. If you're into C, you might find this a lot easier to key in than the assembly language routines above.

```
/*setbaudrate*/
outport(0x3fb,0x80);
outport(0x3f8,0x80);
outport(0x3f9,1);
outport(0x3fb,0x1a);

/*terminalloop*/
do{
if(inport(0x3fd) & 0x01)
 putch(inport(0x3f8));
if(kbhit())
 outport(0x3f8,getch());
}while(1);
```

Once again, we're counting on being able to get out of the loop by hitting control break.

Next month we'll be looking at writing some actual drivers to make our serial port do its stuff elegantly and at reasonable speeds. ■

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FEATURE

Stabilized Power Supplies Part 1

The basic theory of PSU design and how to prevent potential problems.

STEVE KNIGHT

Power supplies often seem to be the poor relations of the electronics scene when it comes to design, un unconsidered trifle to do the job of pumping primary power into your pet project, to be alliterative. One of my acquaintances, not so long ago, built himself an amplifier system with loving care and no expense spared. When he came to use it, it proved to be unstable.

He had obeyed all the rules about ground loops, shielding and all the rest, but he hadn't paid too much attention to his power supply. What problem could there be about that? — transformer, rectifier and a hefty great electrolytic capacitor — oh yes, and a bit of stabilization thrown in.

Easiest part of the project. Well, yes, but it was also the easiest part of the project to cause trouble, which in his case it did. In fact, the bit of stabilization he had thrown in proved to be his downfall. When his amplifier was supplied from a well designed, good quality power unit, it performed as it should.

The moral of this is that a power supply should never be dismissed as something a lot less important than the equipment it supplies. This applies particularly to those among us who dabble and experiment all the time with a variety of circuits and setups; the unit which supplies our power must be above reproach. When something isn't doing what it should, we want to make sure that the power supply is out of the running when we look for the cause.

This short series will introduce a few practical stabilized power unit projects which are reasonably simple to build and have good specifications. To get on our way, we begin this month with some of the elementary theory of stabilized supplies and the problems to be looked for (and avoided) in practical designs.

Types of Supply

Battery supplies and the basic transformer-rectifier-smoothing systems are not our concern here. We shall be interested in those circuits which can be classified under the two main headings of constant-voltage (C-V) and constant-current (C-C) supplies.

A particular power supply may be exclusively designed to operate in one or other of these categories, most commonly the former, but a design is possible in which both modes may be incorporated in a single unit. We begin by looking at the characteristics and evolution of both these systems.

Constant-Voltage Supplies

An ideal voltage supply is defined as an electrical source for which the output voltage remains absolutely constant irrespective of the current being drawn from it. This statement, of course, applies only to the maximum current capacity of which the supply is capable, No source can supply an unlimited current, but within the limit for which it is designed, a constant voltage supply will maintain a constant voltage output independent of the imposed load impedance.

A fully charged car battery is a close approximation to such an ideal source. A

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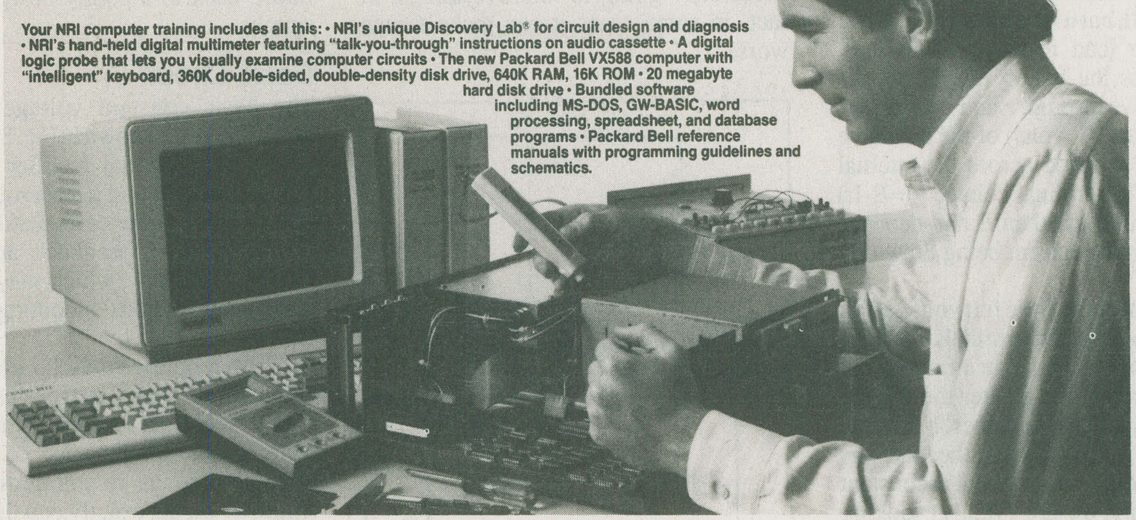

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flat battery is anything but. When your car gives a despairing "clunk" on a cold and frosty morning, you will know what I mean.

The necessary condition for a constant voltage output is *zero* internal impedance. Fig. 1 shows us the real situation; here the voltage source is, for convenience, represented as a battery. This battery, like any other, has an internal resistance *r*. This resistance may be extremely small, but it is never zero.

When a load resistance *R* is connected across the battery terminals, the current *I* flows through *r* and *R* in series, hence in a part (*IR* volts) of the available voltage *E* is dropped across the internal resistance. The terminal voltage *V*(=E-Ir) is consequently *less* than *E* and depends entirely upon the current being drawn by the load.

In fact, of course, the full voltage will only be available at the terminals when the "load" is an open-circuit, an infinite resistance. Otherwise, the greater the current drawn, the smaller *V* becomes, hence the output is not independent of the load current and the source is not the ideal constant voltage supply we are (vainly) looking for. But we are well on our way if we can make the internal resistance extremely small.

However, there is a further complication. Any load device connected to a power supply is rarely of such a form that it requires a constant flow of direct current from the supply.

The load is not often made up of purely passive components such as resistors; active components such as diodes and transistors will be present in the load, hence the current drawn from the supply will be made up of an alternating component superimposed on the direct component. So it is not just a cosy matter of the supply having a zero source impedance at DC, it must have a zero source impedance at *all* frequencies in which the load is likely to be operating.

Suppose by way of an example we have a 25V DC constant voltage power unit having a negligible source resistance at DC but a five ohm resistance at a frequency of 1kHz. If this supply is connected to a load which draws a steady current of 1A on which is superimposed a 1kHz current having peak excursions of +/- 0.1A (see Fig. 2), the power supply will deliver an output which is varying sinusoidally between 24.5V and 25.5V at a 1kHz rate.

Don't confuse this situation with mains "ripple" coming from the power unit. Connecting an additional smoothing capacitor across the output terminals is not necessarily going to improve things, in fact, in some cases it can make things worse.

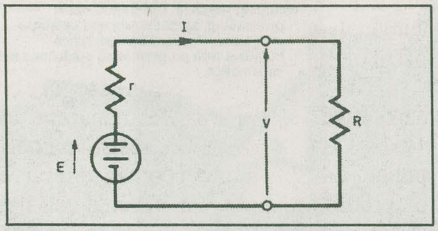

Fig. 1. The circuit conditions for a constant voltage output.

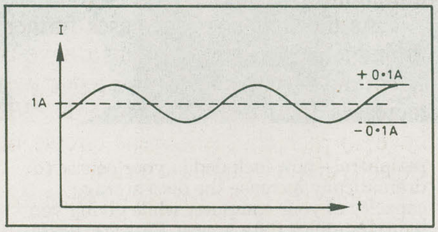

Fig 2. The effects of superimposing a 1kHz current with peak excursions of +/- 0.1A on a load that draws a steady 1A.

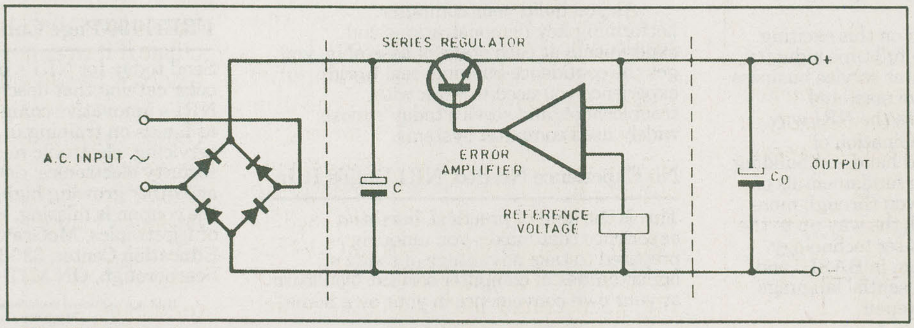

Fig. 3. The basic constant voltage regulated power supply.

Additional to the fact that our power supply fails to provide us with a truly constant voltage, there is the possibility that the variation in the output will be coupled into some other load or to some other part of the connected circuitry fed from the supply. This can constitute an undesirable coupling which may result at best in noisy performance from low level amplifier stages or at worst oscillation over the entire system.

Because it is not possible to build a power supply having zero source impedance at all frequencies, all practical designs have to be a compromise between the ideal and whatever the state of the art happens to be at the time. Of course, for amateur experimenters and dabblers in general, many of the sophisticated features of a high quality power unit design are perhaps academic, but it is necessary to be aware of such aspects for all that. Many a frustrating problem can often be traced back to a poorly designed power supply.

Basic Circuit

The basic constant voltage regulated power supply is shown in Fig. 3. If consists of the conventional rectifier (usually a "diode bridge") and a reservoir capacitor *C*, followed by a series regulator transistor controlled by a feedback amplifier, a reference voltage (which may be adjustable) and an output (smoothing) capacitor C0.

The amplifier may be in integrated circuit form or made up from discrete transistors. Whatever its form, it continuously controls the conductance of the series transistor so as to maintain the two amplifier inputs exactly equal; hence the voltage at the output terminals is held equal to the reference voltage.

The amplifier, for this reason, is often known as the *error* amplifier. There are of course a number of practical variations on this setup, but the overall function comes to the same thing.

Suppose for the moment we imagine the circuitry between the broken lines in Fig. 3 to be eliminated, so that we have the most simple power supply of rectifier bridge and filter capacitor C0 alone. The output impedance of the supply will be that of the capacitor.

Since we want the output impedance to be as small as possible, a large value electrolytic is used in this position. This is all right at frequencies between DC and a few thousand hertz, but the impedance of any capacitor (particularly electrolytics) is not capacitive at all frequencies.

At very low frequencies, the impedance of a capacitor is mainly reactive with a bit of resistance and is relatively large, anyway. At high frequencies the impedance is no longer purely capacitive reactance but has associated with it both

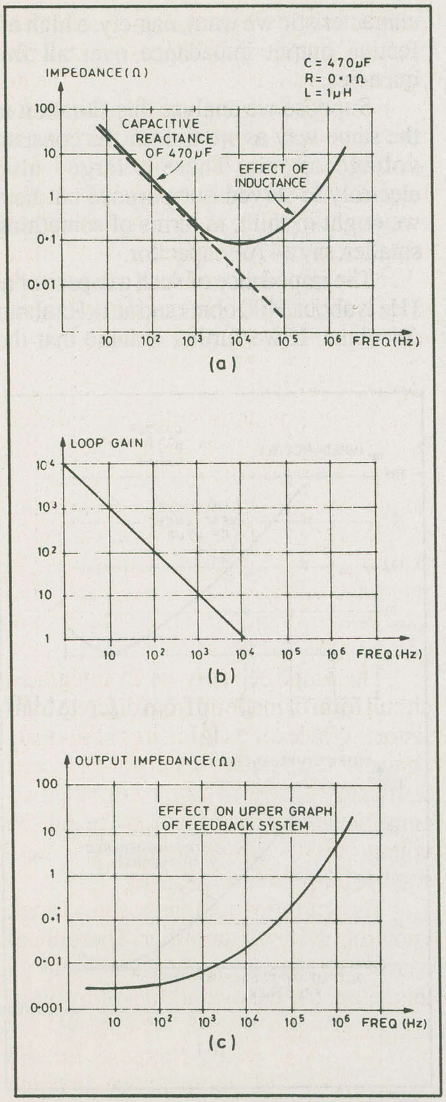

Fig.4.(a) Impedance versus frequency characteristic using a 470u electrolytic capacitor, (b) loop gain and (c) overall output impedance.

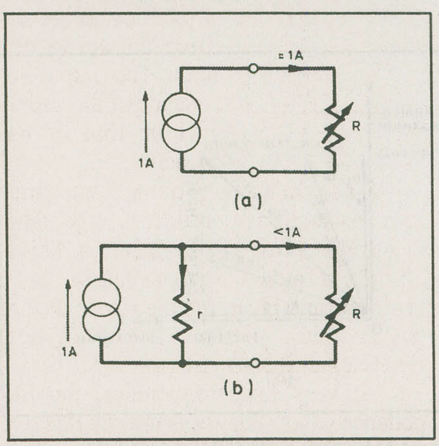

Fig.5. Idealized constant current source and (b) the practical effect of the internal resistance "r" on the output.

resistance and inductance resulting from the finite connecting leads and the constructional form of the component.

For this reason it is common practice to shunt an electrolytic with a small value ceramic capacitor having a negligible inductive reactance at the highest operating frequency. It is not enough just to think about the 100Hz ripple frequency coming from the rectifier.

Impedance Versus Frequency

A typical impedance versus frequency characteristic for a 470uF electrolytic capacitor is shown in Fig.4(a). We have assumed that this capacitor has a resistance of 0.1 ohm and an inductance of 1uH.

The impedance (almost purely capacitive) at 10Hz is 34 ohms and at 1kHz it is 0.34 ohm. The resistive component of 0.1 ohm becomes effective before this frequency is reached and the curve, which would otherwise follow the broken line, levels out at the impedance minimum of 0.1 ohm.

As the frequency increases further, the inductive component begins to have its effect and the impedance (now inductive) increases from this point onwards. WE have, in effect, a resonant circuit of capacity and inductance in series.

When the regulator circuit is added, its effect is to make the supply output impedance at each frequency *lower* than the impedance of the capacitor alone by a factor equal to one +loop gain of the feedback amplifier at the same frequency. This result comes from feedback theory.

Since the loop gain of the amplifier will be very much greater than one over most of the frequency band of interest, we can treat (one +loop gain) as being simply (loop gain). Hence supposing the amplifier gain to be 10,000 (10/4) at 1Hz falling linearly to unity at 10kHz (10/4Hz) as shown in Fig. 4b, the characteristic of Fig. 4a becomes that of Fig. 4c which shows the resulting *overall* output impedance of the supply.

This is a big improvement over the first graph, particularly for frequencies up to about 5 X 10/4Hz where the impedance remains below 0.1 ohm. At frequencies up to 10/3Hz the amplifier gain is high and the output impedance is correspondingly low, less than 0.01 ohm. At frequencies from 10/3 to about 10/4 the output impedance remains reasonably low because some amplifier gain remains and the impedance of the output capacitor is also low throughout this range.

At those higher frequencies which are beyond the upper bandwidth figure for the amplifier the output impedance is and remains inductive, depending solely on the characteristics of the output capacitor and the effect of the wires connecting it to the actual output terminals. And, of course, anything beyond that. The curves are illustrative only and are not derived from any actual power unit, though they are quite typical of practical systems.

From all this it might seem that by making the gain of the amplifier large enough we could achieve the magical zero output impedance. Alas, this is not so. No amount of gain, however great, will be enough to reduce the output impedance to zero.

But this doesn't mean that a zero impedance is impossible to achieve. It is possible, but only by employing positive feedback; just enough positive feedback, in fact, to cause the feedback amplifier to oscillate if it were not held within a negative feedback loop having overall stability.

This call for sophisticated design procedures which are not easy for the amateur to achieve; and in any case such configurations remain for the most part in a designer's laboratory and rarely have significant practical applications. But it's a thought, perhaps, for those of us who like to dabble in such things.

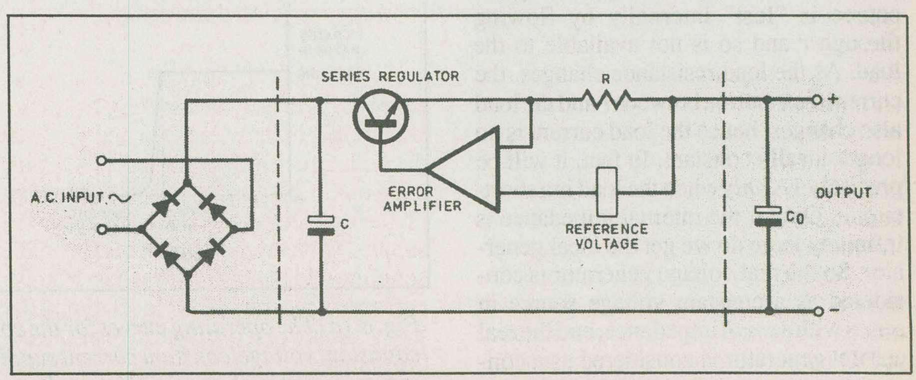

Fig.6. Block diagram for a constant current regulated power supply.

Constant-Current Supplies

An ideal current supply is defined as an electrical source for which the current remains absolutely constant irrespective of the voltage demanded by the load. Such a constant current source is generally required for specialized applications and is not so much in demand as constant voltage.

However, there are applications where constant current is a necessity; it may be that a stable magnetic field is required from an electromagnet. If the coil of the magnet is simply placed across a constant voltage source, the current through the coil will depend upon the resistance of the coil. This could change through ambient temperature variations or as the result of self heating. So the current would change and the magnetic field strength might vary sufficiently to invalidate the circuit tolerances within which it operated. If the current can be held constant irrespective of what the coil resistance or the applied voltage does, the problem does not arise.

We have seen that the ideal voltage source should have a zero output impedance. Because it is possible that the load resistance connected to a constant current supply may vary with time, an ideal current source must have an *infinite* internal impedance at all frequencies.

This concept might be more difficult to understand than it was in the case of a voltage source. Let me illustrate with a simple example. Fig. 5a shows a hypothetical generator that will deliver a current of, say 1A irrespective of whatever value the load resistance *R* takes, including a short-circuit. This is the ideal case. In real life, something is present which prevents this happening. This something is again the internal impedance which we represent this time as a resistance *r* in *parallel* with the perfect generator, see Fig. 5b. In this situation some of the 1A current supplied by the source is "lost" internally by flowing through *r* and so is not available to the load. As the load resistance changes, the current distribution between *r* and the load also changes; hence the load current is no longer ideally constant. In fact, it will be precisely 1A *only* when the load is a short-circuit. Only if the internal impedance is infinitely large do we get the ideal generator. So the real voltage generator is considered as a constant voltage source in series with a *small* impedance, and the real current generator is considered as a constant current source in parallel with a *large* impedance.

Basic Circuit

The block diagram of a constant current regulated power supply is shown in Fig. 6. The bridge rectifier and reservoir capacitor are identical with that of the constant voltage supply, and the other component parts are similar in form also.

However, instead of comparing the reference voltage with the output voltage, the error amplifier compares the reference voltage with the *voltage drop* caused by the output current flowing through a current monitoring resistor *R*. The action of the feedback loop is then similar to that of the constant voltage system; the conductance of the series transistor is varied in such a way that the voltage drop across *R* is maintained equal to the reference voltage, thereby holding the output current to a fixed value.

In a constant current supply, the output impedance without feedback is made up of the output capacitor C0 effectively in parallel with the current monitoring resistor *R*. This assumes that the impedance looking back into the series regulator and the rectifier is small compared with the resistor.

The effect of current derived feedback is then, from feedback theory, to *multiply* the effective value of the monitoring resistance by the loop gain of the amplifier throughout its frequency range, this increased resistance still remaining in parallel with the output capacitance. And at this point we meet another problem. Since the output capacitor behaves as a low impedance, particularly as the frequency increases, a large value electrolytic of the kind conventionally put across the output terminals of a power unit for its so-called smoothing effect is actually working to the detriment of the constant current characteristic we want, namely, a high effective output impedance over all frequencies.

Suppose we analyse this situation in the same way as we did for the constant voltage circuit. There a large value electrolytic served our purpose but here we ought to think in terms of something smaller, say a 47uF capacitor.

The impedance of such a capacitor at 1Hz is about 3400 ohms and at 1kHz about .34 ohms. If we further assume that the

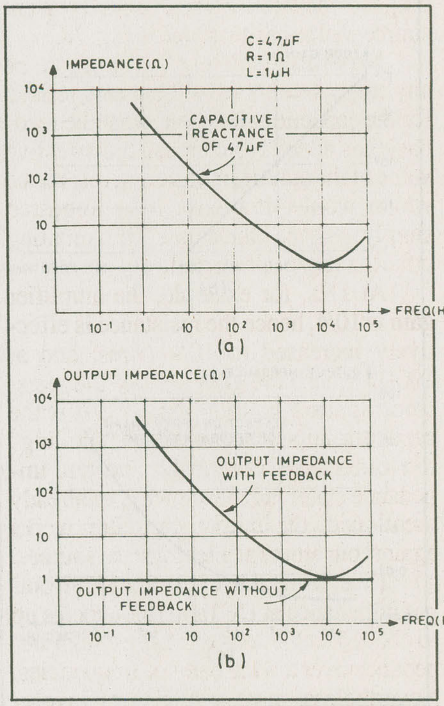

Fig. 7. (a) Impedance versus frequency characteristic of the output circuit using a 47u electrolytic capacitor, and (b) overall output impedance of the constant currrent source with feedback.

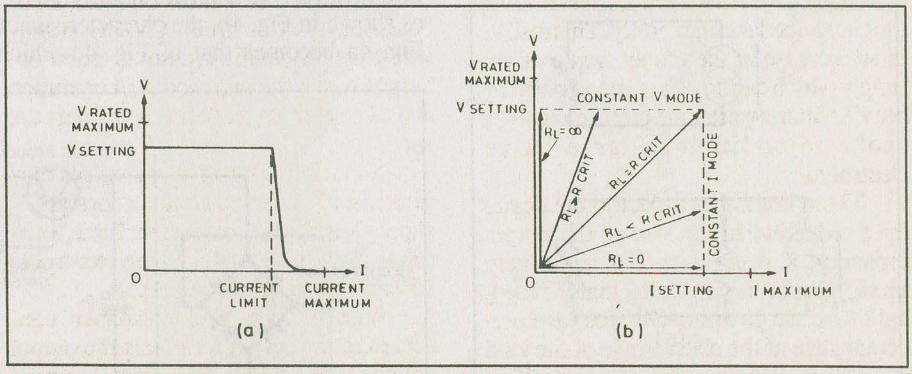

Fig. 8. (a) The operating curves for the constamt voltage supply (CV) and (b) the copnstant voltage/constant current supply (CV/CC). The switchover or limiting point is determined by the setting of the voltage and current controls.

current monitoring resistor is one ohm (a common value), then the impedance versus frequency characteristic of the output circuit will be as shown in Fig. 7a.

While the capacitive reactance is dominant, the impedance falls as the frequency increases, but the inductive component takes over at around 10kHz and causes the impedance to rise again. If we take the gain characteristic of the feedback amplifier to be the same as that mentioned for the constant voltage supply (Fig. 4b), and combine this with Fig. 7a, the overall output impedance of the constant current source will be as illustrated in Fig. 7b.

Now this graph may not appear to be any improvement over the characteristic for the capacitor alone, but what the feedback has done is to increase the effective value of the parallel monitoring resistance which would otherwise have appeared simply as a one ohm shunt. This shunting effect has been eliminated.

At 1Hz, for example, the amplifier gain is 10/4, hence the resistance is effectively increased to 10/4 ohms; and at 100Hz where the gain is 10/2 the resistance appears as 10/2 ohms. So it is the capacitor impedance which is "spoiling" the otherwise favourable output impedance state; the reason why, as already mentioned, the output capacitor works against our aim of an ideal current source.

Thus, while the supply has a high output impedance at DC (and frequencies up to about 1Hz) it does not have a high impedance over a wide band of frequencies. Nevertheless, most applications involving constant current supplies require a high impedance only at DC and are not severely affected by the low impedance at high frequencies.

The problem is sometimes reduced by removing the bulk of the output capacitance from the circuit, so permitting a higher impedance generally. This results in an increase in the output ripple of the supply which can be offset up to a point by heavier filtering after the rectifier, using a choke in addition to large value electrolytics.

There is another aspect to the desire for a reduction in the size of the output capacitor; if it is omitted or made very small, there is the possibility that the feedback loop can go into oscillation for a particular state of the phase angle of the load impedance. This usually shows itself as oscillation at a very low or a very high frequency.

There is not a lot to be gained from an extremely high gain amplifier either. No finite amount of gain will ever cause the output impedance to become infinite. Like its constant voltage counterpart, it *is* possible to provide positive feedback to give an infinite impedance at DC but this is fraught with design problems not recommended for amateur project work.

Current Limiting

It is not desirable that a power supply unit should be able to provide a maximum *instantaneous* current. The reasons for this are: (a) it might be damaging to the series regulator, and (b) it might be sufficient to blow a fuse or trip a circuit breaker on the power supply by suddenly charging a large load capacitance.

Consequently, it is necessary for a power unit to have some sort of current limiting protection circuit which will restrict the maximum output current under any imposed load condition. This protection circuit may have a fixed or an adjustable current setting.

When a supply is being used well below its rated current maximum, it is still possible that although the supply unit itself is in no danger, the load circuit may be unprotected, in so far as the magnitude of the current available, even though limited, is much higher than the normal load requirement. A careless or accidental interconnection with the load circuitry might allow a large current to flow in part of it and cause damage. Consequently, it is necessary to make the current limiting point adjustable rather than fixed so that the current limit can be set to a value which cannot damage the load device even in the event of an inadvertent short-circuit during experimentation or setting-up.

Any constant voltage supply incorporating a current limiter is essentially a unit having a built-in adjustable constant current supply. This situation must not be confused with a "true" CV/CC supply where an automatic crossover point occurs between the two modes of operation and two separate feedback amplifiers are used.

An example using actual values may illustrate this point better. On a normal CV supply having a preset current limit, let us suppose we have set the voltage control to 15V and the current level to 0.5A.

With a large load resistance connected to the output terminals the output voltage will be 15V and a small current will flow into the load. As the load resistance is reduced, the current will rise but he voltage will remain at 15V until the load resistance reaches 30ohms.

The current will then be at its permitted maximum of 0.5A. Any further decrease in the load will not increase the current but the voltage will fall rapidly, reaching zero when the load is a short-circuit; the current, of course, still remains at 0.5A.

This is the operation of a normal constant-voltage current- limited source. For the true CV/CC supply, the transition point corresponds to an automatic switchover from the CV feedback amplifier to the CC feedback amplifier; decreasing the load from that point on keeps the current at a constant 0.5A while the output voltage drops by exactly the right amount to maintain that current constant through the load provided.

The switchover point occurs at the critical value of the load, R/crit determined by the settings of the voltage and current controls. Fig. 8 shows the operating curves for the CV supply at (a) and the CV/CC supply at (b).

Next month, zener diode stabilizers and fixed regulators using the 78/79 series as an example. ■

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Complementing Book PB74, "Electronic Music Projects", BP174 provides projects, such as a flanger, a phaser, mini-chorus and ring modulators, percussion synths, etc. Each project has an Introduction circuit diagram and constructional notes.

BP113: 30 SOLDERLESS BREADBOARD PROJECTS - BOOK 2 *$9.00*
R.A. Penfold
A companion to BP107. Describes a variety of projects that can be built on plug-in breadboards using CMOS logic IC's. Each project contains a schematics, parts list and operational notes.

BP150: AN INTRO TO PROGRAMMING THE SINCLAIR QL *$7.80*
Helps the reader make the best use of the Sinclair QL's almost unlimited range of features. Complements the manufacturer's handbook.

BP192: MORE ADVANCED POWER SUPPLY PROJECTS *$8.00*
Robert Penfold.
A companion to BP76, this book covers switched mode supplies, precision regulators, tracking regulators, computer-controlled supplies, etc.

BP222: SOLID STATE SHORT WIVE RECEIVER FOR BEGINNERS *$7.80*
R.A. Penfold
In this book, R.A. Penfold has designed and developed several modern solid state short wave receiver circuits that will give a fairly high level of performance, despite the fact that they use only relatively few and inexpensive components.

BP197: INTRODUCTION TO THE AMSTRAD PCs *$20.00*
The Amstrad PC is an MS- DOS computer for general and business use. This book explains all you need to know to start computing.

BP48: ELECTRONIC PROJECTS FOR BEGINNERS *$7.80*
F.G. Rayer, T. Eng. (CEI), Assoc.IERE
In this book, the newcomer to electronics will find a wide range of easily made projects. Also, there are a considerable number of actual components and wiring layouts, to aid the beginner.

BP135: SECRETS OF THE COMMODORE 64 *$5.85*
This book is intended as a beginner's guide to the Commodore 64.

BP155: INTERNATIONAL RADIO STATIONS GUIDE *$9.00*
An invaluable aid in helping all those who have a radio receiver to obtain the maximum entertainment value and enjoyment from their sets.

BP130: MICRO INTERFACING CIRCUITS — BOOK 1 *$9.00*
Aimed at those who have some previous knowledge of electronics, but not necessarily an extensive one, the basis of the book is to help the individual understand the principles of interfacing circuits to microprocessor equipment.

BP131: MICRO INTERFACING CIRCUITS — BOOK 2 *$9.00*
Intended to carry on from Book 1, this book deals with practical applications beyond the parallel and serial interface. "Real world" interfacing such as sound and speech generators, temperature, optical sensors, and motor controls are discussed using practical circuit descriptions.

BP51: ELECTRONIC MUSIC AND CREATIVE TAPE RECORDING *$5.85*
This book sets out to show how Electronic Music can be made at home with the simplest and most inexpensive equipment.

BP74: ELECTRONIC MUSIC PROJECTS *$10.00*
R.A. Penfold
Although one of the more recent branches of amateur electronics, electronic music has now become extremely popular. The purpose of this book is to provide the constructor with a number of practical circuits for the less complex items of electronic music equipment, including such things as a Fuxx Box, Waa-Waa Pedal, Sustain Unit, Reverberation and Phaser Units, Tremelo Generator, etc.

BP110: HOW TO GET YOUR ELECTRONIC PROJECTS WORKING *$7.80*
R.A. Penfold
We have all built circuits from magazines and books only to find that they did not work correctly, or at all, when first switched on. This book will help the reader overcome these problems by indicating how and where to start looking for many of the common faults that can occur when building up projects.

BP86: AN INTRODUCTION TO BASIC PROGRAMMING TECHNIQUES *$5.85*
This book is based on the author's own experience in learning BASIC and also in helping others, mostly beginners to programming, to understand the language.

BP234: TRANSISTOR SELECTOR GUIDE *$15.00*
Listings of British, European and eastern transistor characteristics make it easy to find replacements by part number or by specifications. Devices are also grouped by voltage, current, power, etc., includes surface-mount conversions.

BP233: ELECTRONIC HOBBYIST HANDBOOK *$15.00*
A single source of easily located information: colour codes, pinouts, basic circuits, symbols, etc.

BP101: HOW TO IDENTIFY UNMARKED IC's *$1.95*
An unusual and fascinating chart that is highly recommended to all those interested in electronics and which will hopefully pay for itself many times over, by enabling the rEader to use IC's that might otherwise have been scrapped.

BP121: HOW TO DESIGN AND MAKE YOUR OWN PCBs *$5.85*
The purpose of this book is to familiarize the reader with both simple and more sophisticated methods of producing printed circuit boards. The book emphasizes the practical aspects of printed circuit board designs and construction.

BP125: 25 SIMPLE AMATEUR BAND AERIALS *$5.85*
This book describes how to build 25 amateur band aerials. The designs start with the simple dipole and proceed to beam, triangle and even a mini-rhombic.

BP180: ELECTRONIC CIRCUITS FOR THE COMPUTER CONTROL OF MODEL RAILWAYS *$9.00*
Shows how home computers can easily be applied to the control of model railroads and other quite sophisticated control. A variety of projects are discussed as well as circuits for train position sensing, signal and electric points control, etc.

BP100: AN INTRODUCTION TO VIDEO *$5.85*
This book is for the person who has just, or is about to buy or rent video equipment but is"nt sure what it's all about.

BP78: PRACTICAL COMPUTER EXPERIMENTS ***$5.25***
The aim of this book is to enable the reader to simply and inexpensively construct and examine the operation of a number of basic computer circuit elements and it is hoped gain a fuller understanding of how the mysterious computer "chip" works.

BP185: ELECTRONIC SYNTHESIZER CONSTRUCTION ***$9.00***
With this book a relative beginner should be able to build, with a minimum of difficulty and at a reasonably low cost, a worthwhile monophonic synthesizer and also learn a great deal about electronic music synthesis in the process.

BP115: THE PRE-COMPUTER BOOK ***$5.85***
Aimed at the absolute beginner with no knowledge of computing, this entirely non-technical discussion of computer bits and pieces and programming is written mainly for those who do not possess a microcomputer but either intend to one day own one or simply wish to know something about them.

BP92: ELECTRONICS SIMPLIFIED - CRYSTAL SET CONSTRUCTION ***$5.25***
This is a book written especially for those who wish to participate in the intricacies of electronics.

BP72: A MICROPROCESSOR PRIMER ***$5.25***
In an attempt to give painless approach to computing, this inexpensive book will start by designing a simple computer and then the short-comings of this simple machine will be discussed and the reader is shown how these can be overcome. Includes a glossary of microprocessor terms.

BP42: 50 SIMPLE L.E.D. CIRCUITS ***$5.85***
Contains 50 interesting and useful circuits and applications, covering many different branches of electronics, using one of the most inexpensive and freely available components.

BP85: INTERNATIONAL TRANSISTOR EQUIVALENTS GUIDE ***$9.00***
This book is designed to help the user find possible substitutes for a popular user-oriented selection of modern transistors and includes devices produced by over 100 manufacturers.

BP140: DIGITAL IC EQUIVALENTS AND PIN CONNECTIONS ***$15.00***
Shows equivalents and pin connections of a popular user- oriented selection of Digital Integrated Circuits. Includes European, American and Japanese devices.

BP136: SIMPLE INDOOR AND WINDOW AERIALS ***$7.00***
People living in apartments who would like to improve shortwave listening can benefit from these instructions on optimizing the indoor aerial.

BP156: AN INTRODUCTION TO QL MACHINE CODE ***$10.00***
The powerful sinclair QL microcomputer has some outstanding capabilities in terms of its internal structure. With a 32-bit architecture, the QL has a large address range, advanced instructions which include multiplication and division.These features give the budding machine code programmer a good start at advanced programming methods. This book assumes no previous knowledge of either the 68008 or machine code programming.

BP59: SECOND BOOK OF CMOS IC PROJECTS ***$7.80***
This book carries on from its predecessor and provides a further selection of useful circuits, mainly of a simple nature. The book is well within the capabilities of the beginner and more advanced constructor.

BP258 LEARNING TO PROGRAM IN C ***$19.00***
This book is a guide to C programming. C statements are introduced and explained with the help of simple, but completely working programs.

BP141: LINEAR IC EQUIVALENTS AND PIN CONNECTIONS ***$23.80***
Adrian Michaels
Find equivalents and cross-references for both popular and unusual integrated circuits. Shows details of functions, manufacturer, country of origin, pinouts, etc... includes National, Motorola, Fairchild, Harris, Intersil, Philips, ADC, AMD, SGS, Teledyne, and many others.

BP7: RADIO AND ELECTRONICS COLOUR CODE AND DATA CHART ***$3.00***
Opens out to Wall Chart approximately 584 X 457mm. Includes many Radio & Electronics Colour Codes in use in UK, USA, Europe and Japan. Covers Resistors, Capacitors, Transformers, Field Coils, Fuses, Battery Leads, etc.

BP225: A PRACTICAL INTRODUCTION TO DIGITAL ICs ***$7.00***
This book deals mainly with TTL type chips such as the 7400 series. Simple projects and a complete practical construction of a Logic Test Circuit Set are included as well as details for a more complicated Digital Counter Timer project.

BP147: AN INTRODUCTION TO 6502 MACHINE CODE ***$10.00***
The popular 6502 microprocessor is used in many home computers; this is a guide to beginning assembly language.

BP88: HOW TO USE OP-AMPS ***$11.80***
E.A. Parr
A designer's guide covering several op-amps, serving as a source book of circuits and a reference book for design calculations. The approach has been made a non-mathematical as possible.

ELEMENTS OF ELECTRONICS — AN ON-GOING SERIES ***$11.80 EACH OR ALL 5 BOOKS FOR $44.00***
F.A. Wilson, C.G.I.A., C.Eng.,
Although written for readers with no more than ordinary arithmetical skills, the use of mathematics is not avoided, and all the math required is taught as the reader progresses. Each book is a complete treatise of a particular branch of the subject and therefore, can be used on its own with one proviso, that the later books do not duplicate material from their predecessors, thus a working knowledge of the subjects covered by the earlier books is assumed.

BP62: BOOK 1. This book contains all the fundamental theory necessary to lead to a full understanding of the simple electronic circuit and its main components.

BP63: BOOK 2. This book continues with alternating current theory without which there can be no comprehension of speech, music, radio, television or even the electricity utilities.

BP64: BOOK 3. Follows on semiconductor technology, leading up to transistors and integrated circuits.

BP77: BOOK 4. A complete description of the internal workings of microprocessor.

BP89: BOOK 5. A book covering the whole communication scene.

BP194: MODERN OPTO DEVICE PROJECTS ***$9.00***
This book provides a number of practical designs for beginners and experienced project builders. These projects utilize a range of modern opto-electric devices, including such things as fibre optics, ultra-bright LEDs and passive IR detectors.

BP37: 50 PROJECTS USING RELAYS, SCR's & TRIACS ***$7.80***
F.G. Rayer, T. Eng., (CEI), Assoc.IERE.
Relays, bi-directional triodes (TRIACs), and silicon controlled rectifiers (SCRSs), have a wide range of applications in electronics today. This book gives practical working circuits which should present the minimum of difficulty for the enthusiast.. In most of the circuits there is a wide latitude in component values and types, allowing easy modification and adaptation.

BP84: DIGITAL IC PROJECTS ***$7.80***
F.G. Rayer, T. Eng. (CEI), Assoc.IERE.
This book contains both simple and more advanced projects for the reader developing a knowledge of the workings of digital circuits. To help the newcomer to the hobby the author has included a number of board layouts and wiring diagrams.

BP95: MODEL RAILWAY PROJECTS ***$7.80***
Electronic projects for model railways are fairly recent and have made possible an amazing degree of realism. The projects covered included controllers, signals and sound effects: stripboard layouts are provided for each project.

BP144: FURTHER PRACTICAL ELECTRONICS CALCULATIONS AND FORMULAE ***$15.00***
This book covers many aspects of electronics where a knowledge and familiarity of the appropriate formulae is essential for a fuller understanding of the subject. An essential addition to the library of all those interested in electronics.

BP44: IC 555 PROJECTS ***$10.00***
E.A. Parr, B.Sx., C. Eng., M.I.EE.
Every so often a device appears that is so useful that one wonders how life went on before it. The 555 timer is such a device included in this book are Basic and General Circuits, Motor Car and Model Railway Circuits, Alarms and Noise Makers as well as a section on the 556, 558 and 559 timers.

BP94: ELECTRONIC PROJECTS FOR CARS AND BOATS ***$7.80***
R.A. Penfold
Projects, fifteen in all, which use a 12V supply are the basis of this book. Included are projects on Windscreen Wiper Control, Courtesy Light Delay, Battery Monitor, Cassette Power Supply, Lights Timer, Vehicle Immobiliser, Gas and Smoke Alarm, and more.

BP49: POPULAR ELECTRONIC PROJECTS by R. A. Penfold ***$10.00***
Includes a collection of the most popular types of circuits and projects which will provide a number of designs to interest most electronics constructors. The projects cover a wide range and are divided into four basic types. Radio Projects, Audio Projects, Household Projects and Test Equipment.

BP99: MINI-MATRIX BOARD PROJECTS by R. A. Penfold ***$7.60***
Twenty useful projects which can all be built on a 24 X 10 hole matrix board with copper strips. Includes Door-buzzer, Low-voltage Alarm, AM Radio, signal Generator, Projector Timer, Guitar Headphone Amp. and more.

BP103: MULTI-CIRCUIT BOARD PROJECTS by R.A. Penfold ***$7.80***
This book allows the reader to build 21 fairly simple electronic projects, all of which may be constructed on the same printed circuit board. Wherever possible, the same components have been used in each design so that with a relatively small number of components and hence low cost, it is possible to make any one of the projects or by re-using the components and P.C.B. all of the projects.

BP98: POPULAR ELECTRONIC CIRCUITS, BOOK 2 ***$9.00***
R.A. Penfold
70 plus circuits based on modern components aimed at those with some experience.

BP127: HOW TO DESIGN ELECTRONIC PROJECTS ***$9.00***
Although information on stand circuits blocks is available, there is less information on combining these circuit parts together. This title does just that. Practical examples are used and each is analysed to show what each does and how to apply this to other designs.

BP195: AN INTRODUCTION TO SATELLITE TELEVISION ***$15.00***
For the absolute beginner or anyone thinking about purchasing a satellite TV system, the story is told as simply as such a complex one can be.

BP106: MODERN OP-AMP PROJECTS by R. A. Penfold ***$7.80***
Features a wide range of constructional projects which make use of op-amps including low-noise, low distortion, ultra-high input impedance, high slew-rate and high output current types.

BP107: 30 SOLDERLESS BREAD-BOARD PROJECTS - BOOK 1 ***$9.00***
R.A. Penfold
A "Solderless Breadboard" is simply a special board on which electronic circuits can be built and tested. The components used are just plugged in and unplugged as desired. The 30 projects in this book have been designed to be built on a "Verobloc" breadboard. Wherever possible the components used are common to several projects, hence with only a modest number of components it is possible to build, in turn, every project shown.

BP122: AUDIO AMPLIFIER CONSTRUCTION ***$6.75***
A wide circuits is given, from low noise microphone and tape head preamps to a 100W MOSFET type. There is also the circuit for 12V bridge amp giving 18W. Circuit board or strip-board layout are included. Most of the circuits are well within the capabilities of even those with limited experience.

BP179: ELECTRONIC CIRCUITS FOR THE COMPUTER CONTROL OF ROBOTS ***$12.00***
The main stumbling block for most would-be robot builders is the electronics to interface the computer to the motors, and the sensors which provide feedback from the robot to the computer. The purpose of this book is to explain and provide some relatively simple electronic circuits which bridge the gap.

BP108: INTERNATIONALDIODE EQUIVALENTS GUIDE ***$7.00***
Cross-references European, American and Japanese diode part numbers. Besides rectifier diodes, it includes Zeners, LEDs, Diacs, Triacs, SCRs, OCIs, photodiodes, and display diodes.

BP118: PRACTICAL ELECTRONIC BUILDING BLOCKS — BOOK 2 ***$7.60***
R.A. Penfold
This sequel to BP117 is written to help the reader create and experiment with his own circuits by combining standard type circuit building blocks. Circuits concerned with generating signals were covered in Book 1, this one deals with processing signals.

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FEATURE

AutoCAD for Electronics Part 6

Drawing illustrations is easy, even if you aren't skilled in drafting techniques.

BILL MARKWICK

If you've been following along so far, we've accumulated enough commands to draw fairly complicated schematics. Drawing an illustration, such as a chassis or a completed packaging scheme, is straightforward. We'll show this by drawing a 3D view of a chassis—not, alas, a real CAD 3D view (coming soon in a future issue), but a construction using standard isometric drafting techniques.

Don't lose heart if you haven't studied drafting. AutoCAD does it all for you.

Isometrics

In isometric drawing, the artist uses various triangles as a guide to making specified vertical angles and specified horizontal angles — nothing in between. The usual angle for a rectangular box, say, is to tilt it up from the horizontal 30° and swing the far end 30° into the picture. **Fig. 1** illustrates the familiar isometric presentation.

The advantage to this technique of synthesizing 3D out of 2D is that it's convenient and standardized. The disadvantage is that AutoCAD and drafting triangles produce parallel projection; there's no tapering down in size as the far end recedes into the apparent distance. This lack of perspective correction can cause your rectangle to appear wedge-shaped. There are quick fixes for this.

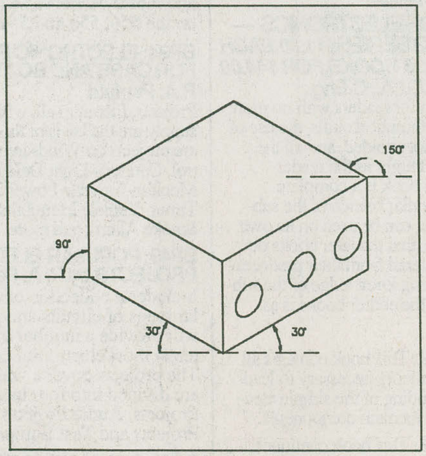


Fig. 1. The standard angles for isometric drawing.

Ortho and Snap

AutoCAD provides some powerful tools for traditional 3D drawing. ORTHO and SNAP are two of these. Ortho allows you to draw only at certain angles, just as drafting triangles do. It's more powerful, of course, because you can choose any angles that suit, and it's Snap that sets these angles for you.

If you have our Almost Free AutoCAD disk, the Mode pulldown menu will let you instantly change from 30° to 150° to standard Snap (see **Fig. 2**). If you don't have the menus, here's how to draw the box using manually-typed commands (and the menu macros are included in case you want to write them into the menu you're using now).

1. Turn on the Grid, Ortho and Snap with F7, F8 and F9.

2. Type SNAP and set the Style to Isometric. Type a Return (for Snap, again) and set the Rotation to zero.

3. Draw the left end of the box with Line or Pline.

4. Type Snap and reset the Rotation to 60.

5. Draw the top and front of the box.

6. Either reset the rotation to zero or reset the Snap to Standard, Ortho off, and draw the missing vertical line at the right end.

MOORSHEAD PUBLICATIONS

SOFTWARE CATALOGUE FALL 1989

MOORSHEAD PUBLICATIONS

SLTH

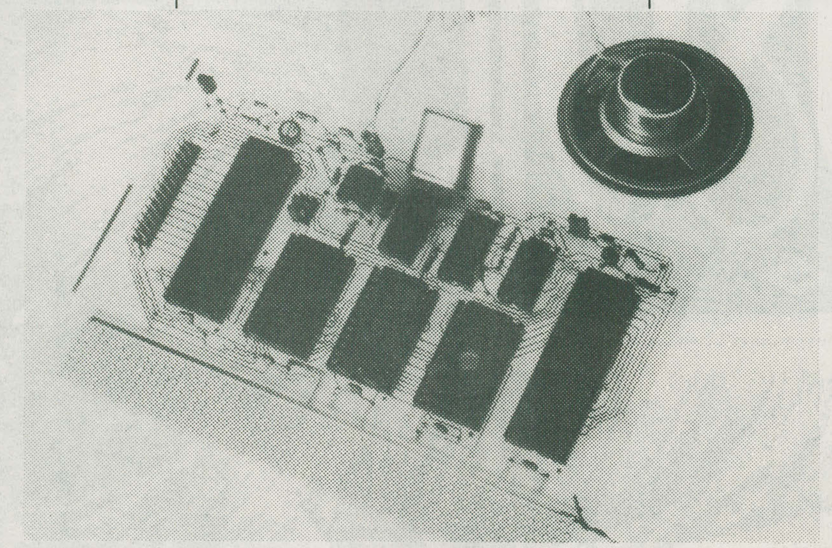
THE COMPUTER THAT CAN'T DO ANYTHING

Computers can do a lot more than just manage data bases and play video games. Specialized microprocessor boards can be used as programmable frequency counters, intelligent temperature controllers, timers, monitors... dedicated microcomputers are at the heart of most of the sophisticated high tech toys that make our lives exciting and our bank balances so easily managed with just a few fingers.

Unfortunately, most individual humans donn't get to work with small, board level micros. These things usually have to be custom designed, which is generally beyond the abilities and the means of most of us. This is unfortunate, as working with compurter hardware at this level is fascinating... and can give one the power to create unspeakably sophisticated projects.

This is why we created the SLOTH. The SLOTH is a small Z80 based computer which is designed to be turned into things. It has no screen, keyboard, floppy disks or printer port... but it's easy to get parts for, quick to assemble and painless to program. It has powerful I/O facilities to allow you to interface it to anything you want to make it work with, from the remote control of a video recorder to the ignition of your car.

The SLOTH isn't a trainer... it's designed to be built up into working projects. It's programmed with inexpensive 2716 EPROMs. It has twenty-four lines of I/O and three programmable counter timers to talk to the rest of the world with. Included on the main SLOTH board are a speaker driver, two kilobytes of static RAM, a pulse source and jumpers to allow you to configure the system to do what you want it to do.



The basic SLOTH also comes with a peripheral board to let one's program control a six digit LED display.

If you have a rudimentary knowledge of assembly language programming, a working soldering iron and a burning desire to get into the fast lane of computer technology, you should try the SLOTH. The October 1986 edition of Computing Now! features an extensive look at the construction of the SLOTH board and a sample program for it. Other issues carry some basic SLOTH applications... timers, controllers and other things that can be made with the SLOTH. However, the low cost and flexibility of the SLOTH will unquestionably give you countless ideas for projects of your own.

The SLOTH package available from us includes a bare SLOTH board... both the main processor board and the LED display board... a parts list, a complete schematic and parts overlay, a source listing for an exercise program and a set of article reprints to explain the system in painstaking detail. In addition to this you'll need the parts to stuff the board... which are widely available... and a computer capable of running an 8080 or Z80 assembler and burning the resultant code into 2716 EPROMs. We recommend an Apple compatible system running CP/M with a Multiflex PROM burner or a PC running Z80MU and a PC compatible EPROM programmer. Z80MU, a CP/M emulator for the PC, is available separately from our service for $19.95.

The SLOTH can be whatever you want it to be... it's the most interesting electronics project on the planet. The complete SLOTH package is available for only $37.95.

ORDER THE SLOTH FOR $37.95 (PLUS 8% O.S.T. & $1.50 SHIPPING FROM MOORSHEAD PUBLICATIONS 1300 DON MILLS ROAD, NORTH YORK, ONTARIO M3B 3M8 PHONE: (416)445-5600 FAX: 416-445-8149

MOORSHEAD PUBLICATIONS

ELECTRONICS & TECHNOLOGY SOFTWARE SERIES

VOLUME ONE

This is the first in a series of software collections assembled specifically for people working with electronics and related fields. In it, we have tried to include programs for a variety of interests. The Perfect speaker enclosure design program will appeal to audio enthusiasts... it gives you access to the same sort of calculation facilities that profession speaker engineers use. There are several programs which will be of help to amateur radio operators. Finally, things like BDS will find use in just about any electronic application.

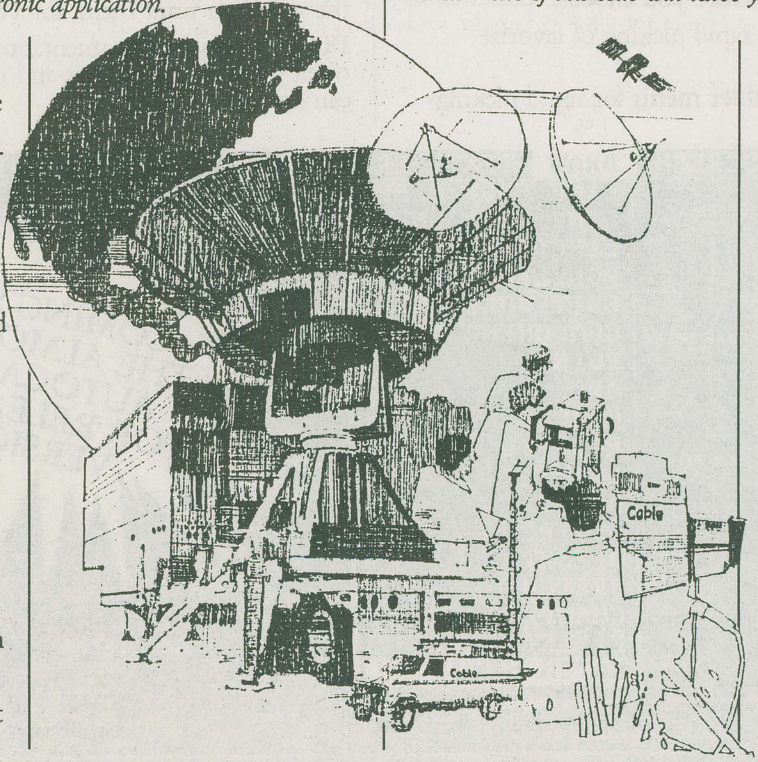
As with all our Almost Free Software collections, this one carries our promise of satisfaction. If, after checking it out, you aren't completely happy with it, we'll buy it back from you with no questions or hassles.

In addition, unlike as with other sources of public domain code, we've scrutinized all of these programs carefully for viruses and other nasties. None of this code will leave your hard drive a smoking ruin.

PERFECT is a powerful system to design speaker enclosures. It allows for a wide variety of general box designs and speaker sizes and impe lances. All you do is to plug ir the appropriate numbers and it will spit out both the dimensions of the box and tell you how it will perform. Saves hours of work and calculations and a lot of wasted wood.

BDS is a pop up utility especially designed for electronics. It performs a number of common calculations, including inductance, capacitance, wavelength and so on. It's better than having a paid lacky with a calculator because you don't have to feed pop up utilities.

DIPOLE is a simple program to handle the calculations for dipole antennas. It's written in BASIC so you can even take it apart and see what it's up to.



GEOS is a great program for finding the location of geo- stationary satellites. It provides everything you need to align a satellite antenna from anywhere in Canada... all without recourse to charts, books, prayer or higher mathematics.

PARABOLA is a BASIC program to help design parabolic antennas. It lets you calculate all the grotty details for anything from a Ku band dinner plate to your own DEW line backscatter radar system.

VSWRCALC calculates voltage standing wave ratios for any wavelength.

YAGI-UDA is a really complex program for an even more complex problem... designing Yagi antennas. Plug in some numbers and it will spit out a sky hook.

FINE PRINT: This software has been collected from public access bulletin boards and/or has been placed directly in the public domain by its authors. It is all believed to be in the public domain, or offered as "shareware". As shareware, users of these programs are requested to pay registration fees to their authors, which may entitle you to additional updates, support and documentation. Note that the fee charged for this disk defers our cost in collecting and distributing the software only, it does not replace any requested shareware contributions. This will help to ensure a continuing supply of high quality shareware available at reasonable prices. If you try out this disk, and do not feel that it is fair value, you may return it for a refund or exchange it for a different disk with no questions asked. We do not sell software to people who cannot use it. If you have trouble with disk, you are welcome to call our free technical support service at (416) 445-5600 during normal business hours. Please be prepared to tell us the exact make and model of your computer and the disk and program you are having difficulty with. Please note that we cannot be respnsible for any loss, damage or expense resulting from your use of this software, however caused.If you are unable to read your disk, it has probably been corrupted in the mail. You need not call us in this case. Simply return the disk to our software department with a note requesting a replacement. It will be shipped immediately. Please note that this disk does presuppose a reasonable familiarity with your computer. If you are very new to your system, we strongly recommend that you familiarize yourself with it before attempting to use almost free software.

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AUTOCAD

VOLUME ONE — RELEASE 9 VERSION

SPEED UP DRAWING AND EDITING IN RELEASE 9 — MINIMIZE TYPING AND CORRECTING!

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A custom pull-down menu with over 150 of the most-often used commands, values and related variables grouped in logical order — almost eliminates searches and menutrees. Includes custom macros that call up a series of commands with a single pick.

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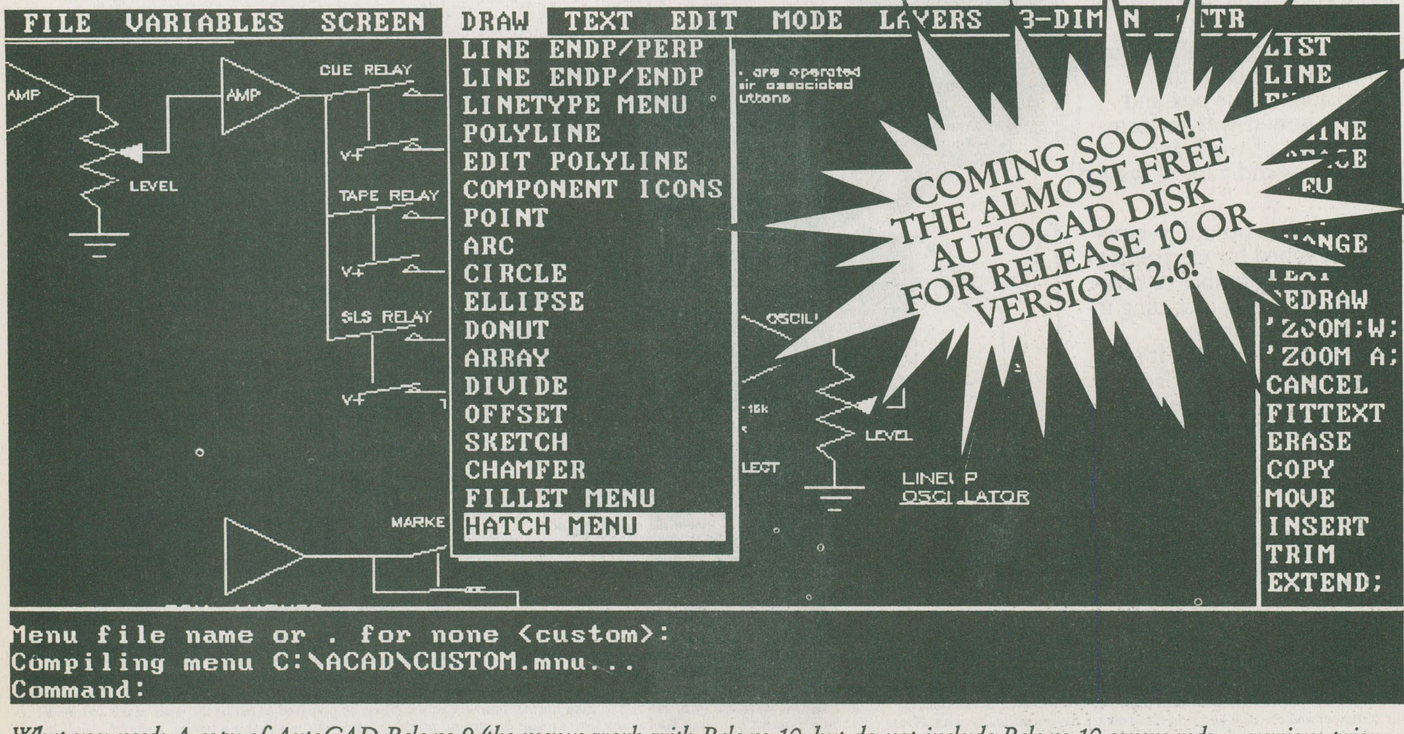
A library of common analog and digital electronic schematic symbols, complete with icon menus for no-typing selection.

PLUS: *All the menus are ASCII files and can be easily changed with your word processor.* Edit the commands just the way you want them, for your style of drawing.

PLUS: complete documentation files with explanations of all the menu structures and macros and how you can change them.



What you need: A copy of AutoCAD Release 9 (the menus work with Release 10, but do not include Release 10 commands — versions prior to Release 9 do not support pulldown menus), a mouse or digitizer tablet (a digitizer is required for the tablet menus) and any version of DOS.

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MOORSHEAD PUBLICATIONS

ALMOST FREE™ SOFTWARE
VOLUME 52

The best things in life are unquestionably almost free. If you want to sample the hottest new software, this collection will get your computer's bytes jumping.

This month's software includes a pop up area code finder that will save you ages of scrambling about in the phone book, a credit card manager which will allow you to keep a leash on your spending and a number of handy DOS utilities. In the ancient tradition of Almost Free Software, there's also a peach of a game... this one with aliens, space ships, phasers, floating eyeballs and all the trimmings.

Every program on this disk has been extensively checked to make sure that it functions as it should and that it contains no viruses or other nasties. Most sources of public domain software do not provide you with this assurance. This disk carries the same promise that all our Almost Free Software does. If you don't feel that it's fair value once you've checked it out, we'll buy it back from you with no gripes or questions. If you have problems with it, our help desk is as near as your phone... just call (416) 445-5600.

If you're not already receiving it, please call us and ask to be put on the mailing list of Personal Software News, our newsletter. It's free.

Note that this is a two disk set containing over a megabyte worth of code. Sorry for the slight price increase... we're certain you'll agree it's worth it.

PC-AREA is the last word in telephone area code programs. Hit the alternate key of your choice and it pops up a window with all the provinces and states in North America, along with a comprehensive area code finder. Let your fingers hoof it in style.

FREEFORM is a data base manager for people who *don't* want to mess about with dBASE. It creates a free form data base which is easy to use, requires no set up and can be keyed by a trained chimp.

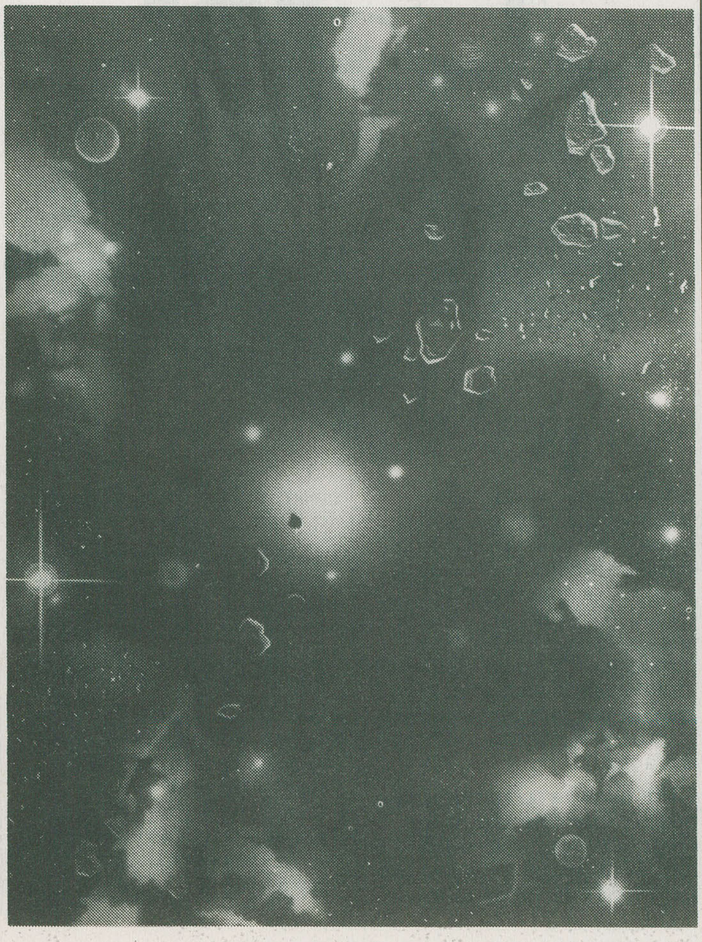
MAZE is a puzzle. It looks simple, but it's a real brain buster. The solution's included in case you get totally frustrated.

OHM-TSR is a handy pop up program which will work out resistor colour codes for you.

STACK is a DOSEDIT replacement from Australia. It keeps a stack of your previous command lines, plus it has a handy pop up window which lets you see all your previous commands at a glance.

CREDIT is a credit card manager, suitable for use in business or to keep track of your personal finances. It helps you refrain from spending yourself into oblivion. Don't leave home without it. Requires Microsoft Windows.

STAR GOOSE is a strange little arcade game in which you fly a space ship over an alien world blasting things into cosmic dust. It's fast and the graphics are superb. EGA or VGA card required.



ALMANAC is a computerized version of the old farmers' almanac that usually accosts you while waiting in the supermarket checkout. Find out what the best days to drill wells are, bring up a host of useful charts and tables and follow the phase of the moon.

VIEW2 is a file view program with schizophrenia. It lets you scroll through two files side by side, allowing you to compare them or just to work with two documents at once.

DUSTY is the last word in Ventura Publisher style sheet utilities. It will create an exhaustive analysis of any style sheet. If you use Ventura you won't want to miss this one.

KBSPEED speeds up the repeat rate of your keyboard... and suddenly, all sorts of programs seem to go a lot faster.

RETPLAN is an RRSP and annuity planner and calculator. It lets you see just how much you'll retire with based on your annual contributions. It's one of the last ways going to get something past the government.

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V O L U M E 5 1

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This collection contains a complete drawing package which while not as powerful as AutoCAD is also nowhere near as hardware or cash hungry. It's also a lot easier to use. There's also POLY, a great little music system. You'll want to check out our DOS utilities, some of which are so good as to be indispensable. Finally, if you have a VGA card we're certain you'll be every bit as blown away by BANANOID as we were. It's the most stunning game available for a PC, commercial or otherwise.

Every program on this disk has been extensively checked to make sure that it functions as it should and that it contains no viruses or other nasties. Most sources of public domain software do not provide you with this assurance.

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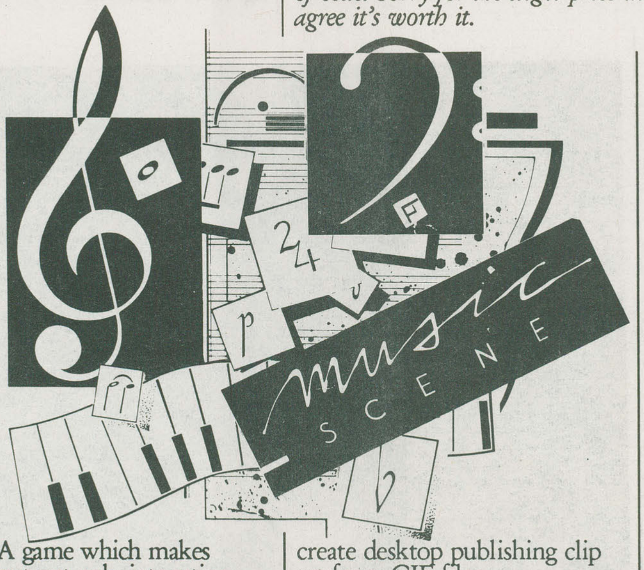

ASCI is a great resident program for applications which require that you enter extended character codes into them. Rather than having to remember what the code for a U with an umlaut over it is, just pop up this window and select it from a table. Great for word processing.

DRAFTC is like AutoCAD without the price tag... and it doesn't need a math chip. This is a complete drafting package with pull down menus, mouse support and lots of features. It's great for applications in which you don't need all the power of a high end drawing program. Requires a mouse.

POLY is a really elegant little three voice music playing program which lets you compose songs with a text editor or word processor and halve them played through your PC's speaker in up to three voices. Sample songs are included.

TRICAL is the most sophisticated pop up calculator program yet devised. Outthinking SideKick and all the commercial calculators, this one will do things even real calculators can't get together.

BANANOID is staggering. It's a VGA game which makes Breakout not only interesting but addictive. Words fail to describe the limitless time wasting potential of this thing. If you own a VGA card and a mouse and go through this life never having play Bananoid, all future incarnations of your spirit will laugh at you behind your collective backs. Requires a VGA card and a mouse.

CLIP allows you to extract sections of GIF files and make them into new, smaller GIF files. It's a great tool if you use our POSTGIF program to create desktop publishing clip art from GIF files.

EGAINT is the last word in Tetris programs. The ultimate falling shape puzzle, this features colour, extended shapes and a plethora of exciting features. Requires an EGA card.

FREEMEM is a little Windows program which puts a window on your screen to tell you the current amount of free memory available to your applications. No computer should be without one. Requires Windows.

NTERNIST is a fascinating and oftentimes useful package to help you figure out... if not cure... what ails you. Give it your symptoms and it'll try to diagnose your condition. This is *not* a substitute for a real physician, but it's great if the provincial health care plan has put you at the back of the waiting list.

PUZZLE is a Windows program which takes one of several graphics, scrambles it into little bits and challenges you to re-assemble it. Quite a decent little program, this. Requires Windows

SUBMIT is an instant batch file. It allows you to run multiple commands at one time from the DOS prompt simply by separating them with colons. An essential gadget, this.

TIME puts a digital clock into a Windows screen. It takes up a lot less space than the one with hands does, and it looks slick. Requires Windows.

TODDY is a DOSEDIT replacement. It adds a sophisticated command line editor to DOS to allow you to recall and edit previous commands. Saves buckets of typing and uses WordStar editing commands.

$24.95 (Two disk set)

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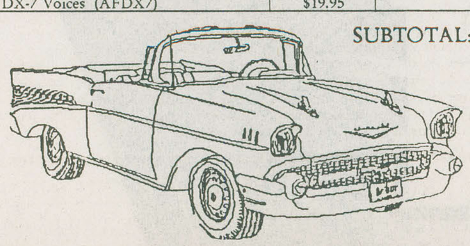

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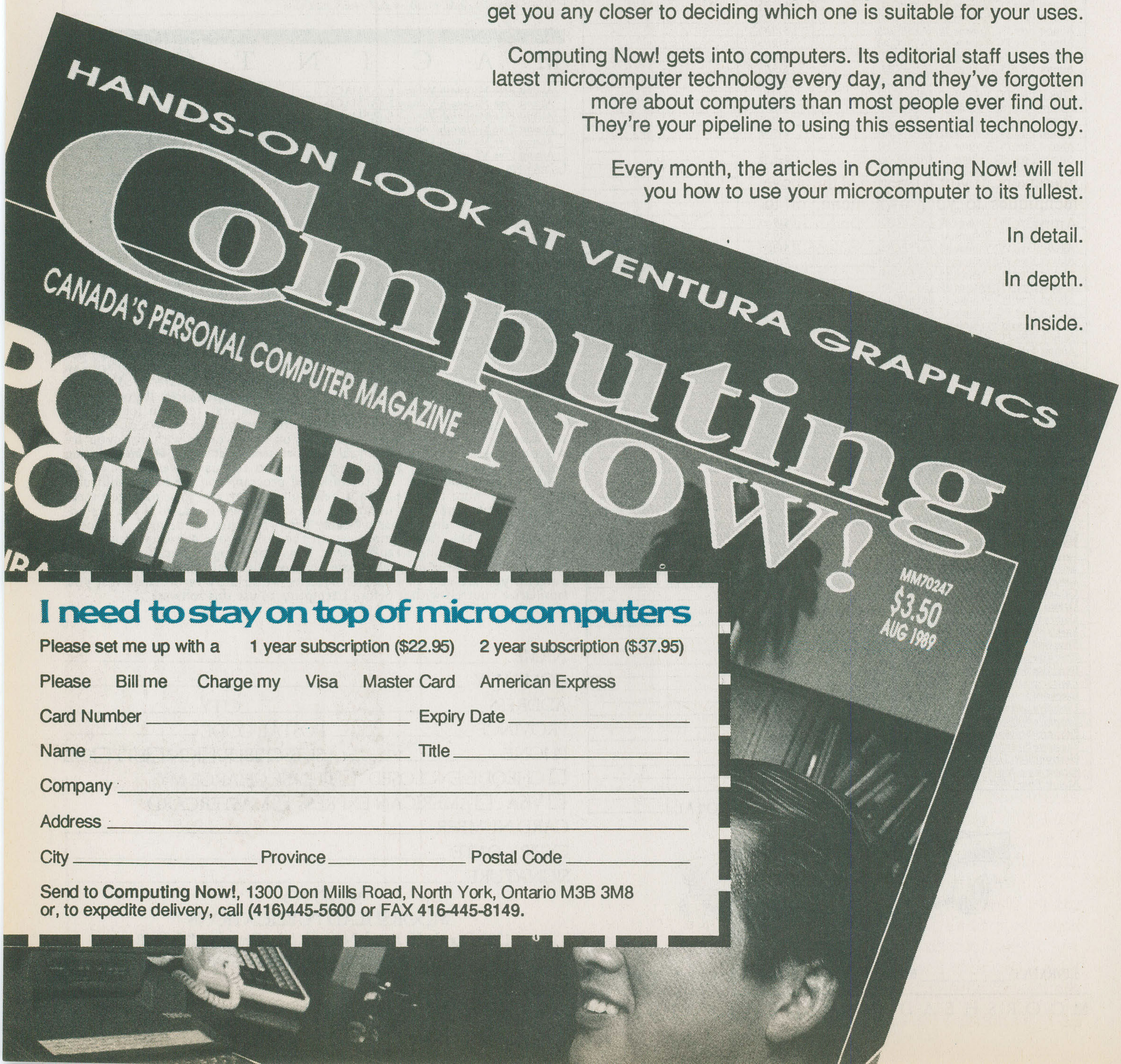

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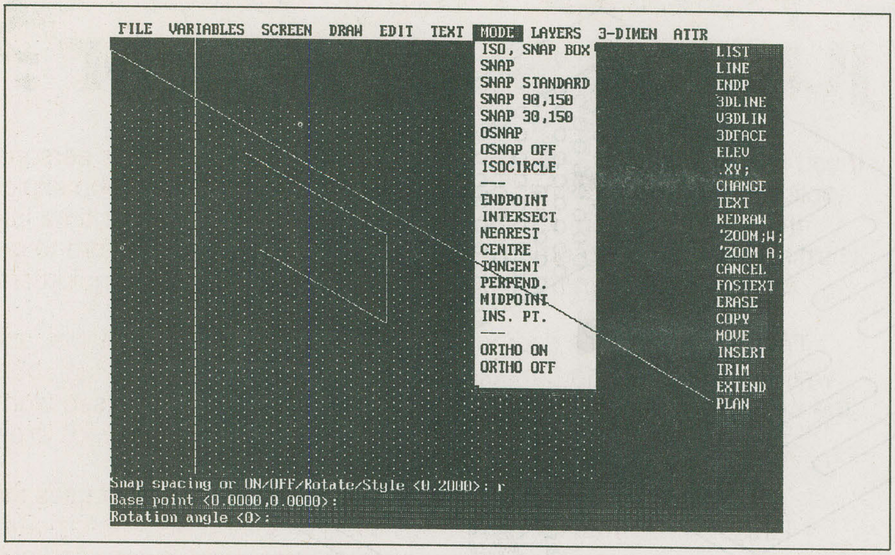

Fig. 2. AutoCAD's display with Ortho and Snap set for isometric drawing. The custom menu from the Almost Free AutoCAD disk provides instant changes to the Snap mode.

And that's it, an isometric box with no guesswork. If you'd like to add the above techniques to your own menu, or to AutoCAD's ACAD.MNU, find a likely spot somewhere in the Draw section of the Screen, Pulldown and/or Tablet menu and add these lines:

```
[SNAPSTANDARD]-
^CSNAP;S;S;SNAP;R;;0
[SNAP90,150]^CSNAP;S;I;;;R;;0;
[SNAP30,150]^CSNAP;S;I;;;R;;60;
[ORTHO ON]^CORTHO ON
[ORTHO OFF]^CORTHO OFF
[ISOCIRCLE]^CELLIPSE;I
[ISOPLANE TOGGLE]ISOPLANE
```

Isocircle? Isoplane?

Isocircles

When you see a circle from some angle other than straight on, it appears to be an ellipse, with the major and minor diameters varying with the viewing angle. AutoCAD figures out how the ellipse should look, and will draw it correctly on one of three planes.

Before adding circles (to represent holes or knobs), type ISOPLANE. It will tell you whether the circle will suit the left, top or right plane of your box. Type Returns until it toggles to the plane you want. Now type Ellipse I, and you'll be set to draw an isocircle of any size with the axes automatically figured out for you.

You may find that the ellipse doesn't suit the plane that you've selected. If this happens, remember that Isoplane finds its way around according to the setting of the Snap mode; reset Snap to 30 or 150 and it should work out properly.

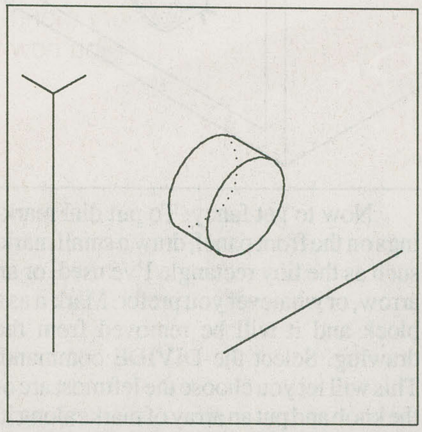

Fig. 3. The knob outline is drawn with two isocircles and the Trim command used to remove hidden lines.

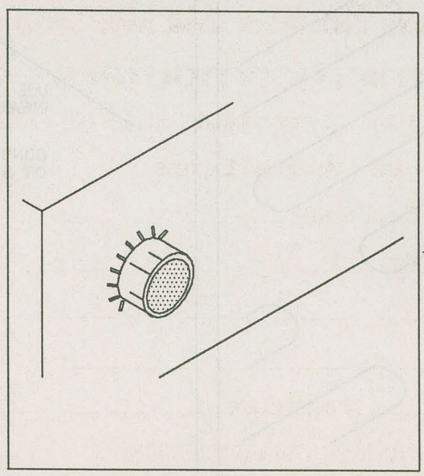

Fig. 4. The knob is dressed up with markings using the Divide command, plus some hatching; it's then marked as a block.

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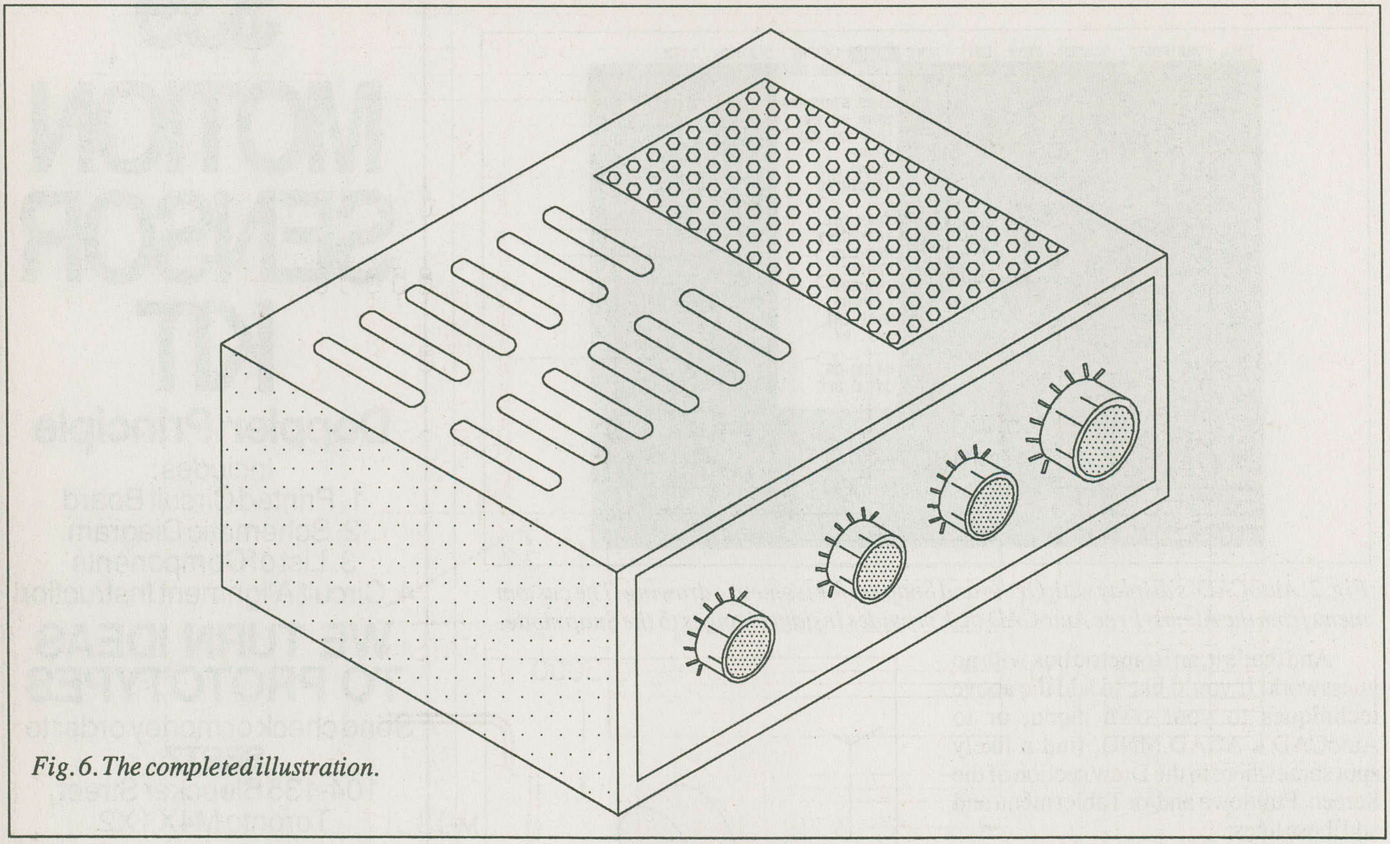

Fig. 6. The completed illustration.

Knobs

Since we're only drawing ellipses, and without much effort at that, we might as well dress them up into proper control knobs. Place two overlapping isocircles as shown in **Fig. 3**; place two connecting lines as shown. Use the Trim command to snip out the arc segments that would be hidden (the dotted line in Fig. 3).

Now to get fancy. To put dial markings on the front panel, draw a small mark, such as the tiny rectangle I've used, or an arrow, or whatever you prefer. Mark it as a block and it will be removed from the drawing. Select the DIVIDE command. This will let you choose the leftmost arc of the knob and put an array of marks along it, automatically aligning them. I found that asking for 12 segments gave a reasonably convincing spacing (I erased the extras). It isn't perfect, but it's adequate for most drawings, and it's very fast.

Add two or three lines to the knob to accentuate the appearance of roundness and put another isocircle inside the knob front. Hatch this circle with your choice of patterns.

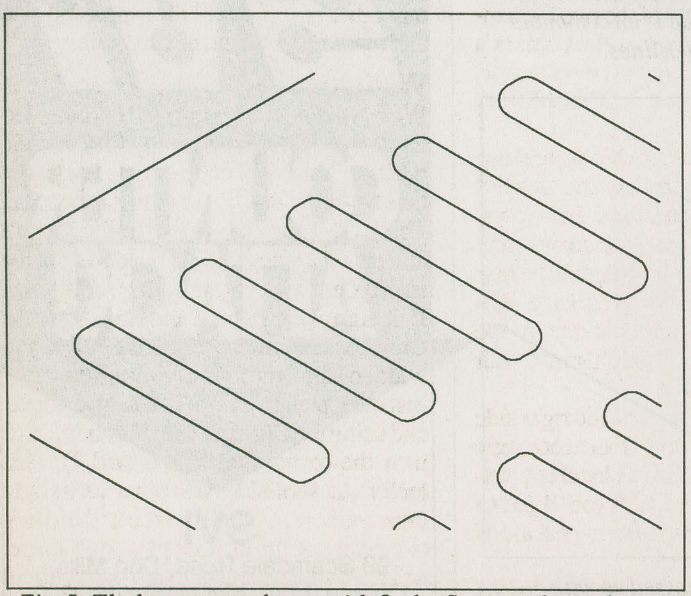

Fig. 5. The louvers are drawn with Ortho/Snap modes and rounded with the Fillet command. The Array command draws the desired rows and columns.

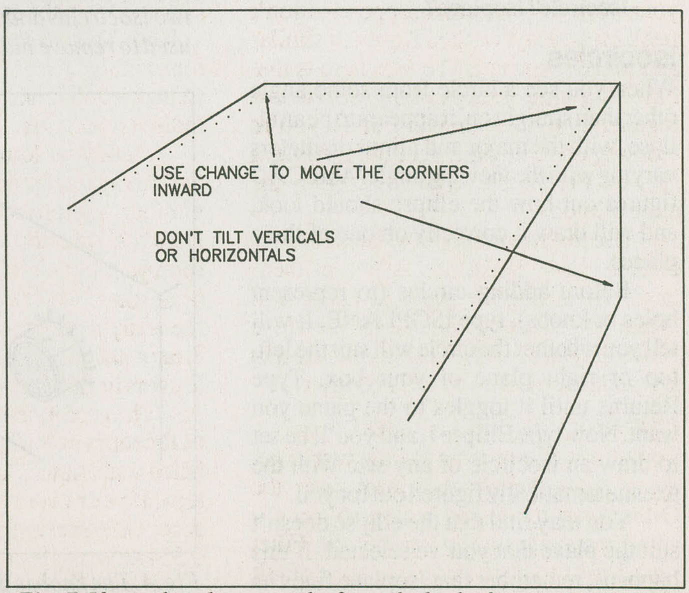

Fig. 7. If a wedge shape results from the lack of perspective correction, use the Change and/or Move commands to reduce the size of the far end by a tiny amount.

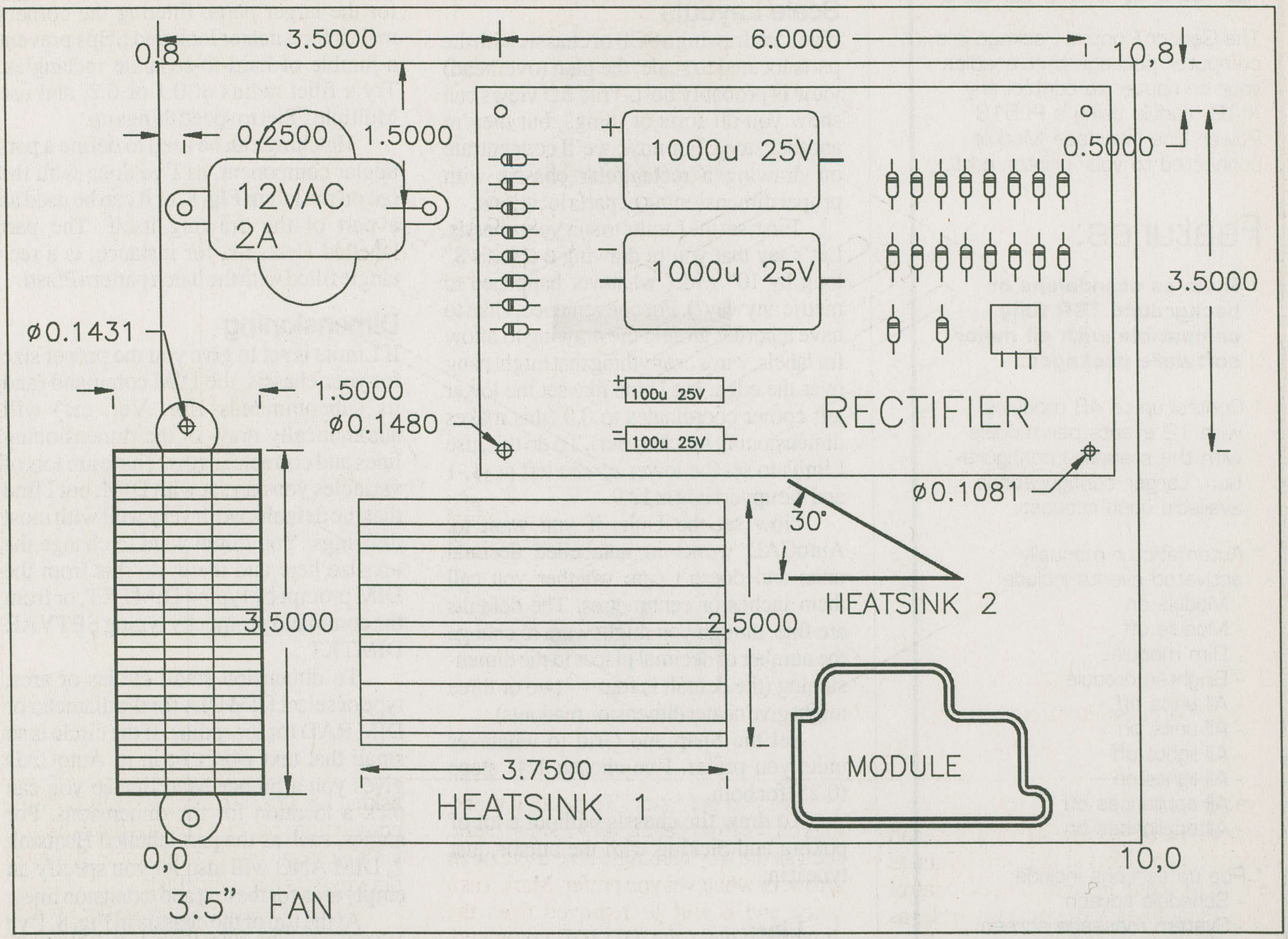

Fig. 8. An example of a scale parts layout drawing. Multiple copies are easily inserted with arrays or the Copy command; the DIM function provides automatic dimensioning.

There you are. Save this as a block (all your work will seem to disappear — don't fret). Make a layer called Knobs or similar and make it current. The idea here is that hatching and arrays slow down the regeneration of the drawing, and if you're working on some other section, you might as well Freeze the layer containing the control knobs.

Use Insert to return some knobs to your control panel. Make one or two of them larger by setting the scale to 1.2 or 1.5. When you're happy with the location (use Move if you're not), change the current layer and Freeze the control knob layer.

Hanging in the Louver

To put some louvers in the top just to get away from the shoebox look, use the Ortho/Snap modes as before to draw a small rectangle on the top. Set the Fillet radius to 0.1 (if you're using the default Limits of 12,9 — otherwise do a bit of experimenting). Fillet the corners of your rectangle; note that the appearance of the rounded corner will vary somewhat, depending on the angle of the two lines involved. This seems to give the corners a reasonably good perspective view, although it will make you think that the fillet radius is changing.

Mark your louvre as a block, and use the Array command to set the desired number of louvre columns and rows. Here's a rub: the Array command may send your louvers climbing up off the box or at some other angle — the trick is that the array's baseline is determined by the Snap rotation angle. 30° should make your louvers line up properly.

The perforated panel on the right side of the top is nothing more than a rectangle filled with AutoCAD's Hex hatching pattern. If your Limits are 12,9 you'll get an acceptable perf look by selecting a scale of 0.35 and an angle of zero.

Put some hatching on the left end of the box just to create the illusion of shadowing.

Thaw the control knob layer and have a look at your completed drawing. Add any other bits of detail that appeal to you and make a test plot at the final size.

Wedgies

When your drawing is plotted or printed to letter size or larger, you may find that the box appears to be wedge-shaped, with the far end somewhat larger than it should be. This lack of perspective correction doesn't always cause trouble; it depends on the size, type of drawing, and other conditions. If it turns out to be a problem, use the Change command to shrink the height and width of the far end by a tiny amount (for instance, pick two lines that form a corner and using the Change Point function, click near the corner (see **Fig. 6 and 7**). This technique should let you put a very slight taper on the box. Don't overdo it; the idea is to cancel out the unwanted wedge shape, and it won't take much. Don't worry about vanishing points and other rules of perspective — there's a fair amount of room for error.

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AutoCAD for Electronics, Part 6

Scale Layouts

If you're drawing a PCB or chassis with the parts located to scale, the plan (overhead) view is probably best. True 3D views can show you all sorts of things, but they're another story. For now, we'll concentrate on drawing a rectangular chassis with proper dimensioning of parts locations.

First, set the Limits to suit your chassis. Let's say that you're drawing a chassis 8" long by 10" wide(whatever happened to metric anyway?). For convenience, I like to have a border around the drawing to allow for labels, wires or anything that might hang over the edge, but I also like set the lower left corner coordinates to 0,0 (this makes dimensioning much easier). To do this, use Limits to set the lower *screen* left at -1,-1 and the upper right at 12,9.

Now set the Units if you want to. AutoCAD works in unlabelled decimal units and doesn't care whether you call them inches or centimetres. The defaults are fine, though you might want to change the number of decimal places in the dimensioning (the default is four — two or three might give neater dimension readouts).

Set the Snap and Grid to whatever units you prefer. I've chosen 1/4" steps (0.25) for both.

To draw the chassis without a lot of poking and picking with the cursor, just type it in:

Line:
from: 0,0 to 0,8 to 10,8 to 10,0 to C

The "C" closes the rectangle and leaves us with an 8 x 10 chassis with some room around it to add extras.

Parts Placement

You can save a lot of time if you make blocks for inserting lots of the same thing. You could make a rectangle, save it as a block, and then insert it with different X and Y scales whenever you need to. It could serve as almost anything, but keep in mind that changing the X and Y scales will defeat certain functions, such as Explode. This means that you can't Fillet the corners, since Fillet expects blocks to be Exploded first.

There are several ways to insert multiple components, such as resistors or capacitors. If they're saved as a block, the MINSERT command combines Insert with Array. If they're not, either Array or Multiple Copy will do it (I always use Multiple Copy — it's much faster than anything else).

Once you've drawn basic rectangles for the larger parts, filleting the corners makes for a neater look and helps prevent a jumble of hard-to-separate rectangles. Try a fillet radius of 0.1 or 0.2, and use Multiple Fillet to speed things up.

Hatching can be used to define a particular component, as I've done with the fan on the left in **Fig. 8**, or it can be used as a part of the drawing itself. The part labelled Heatsink, for instance, is a rectangle filled with the hatch pattern Plasti.

Dimensioning

If Limits is set to give you the proper size for your chassis, the DIM command (and its subcommands Hor, Ver, etc) will automatically draw in the dimensioning lines and correct lengths. There are lots of variables you can set with DIM, but I find that the defaults work very well with most drawings. You might want to change the textsize here and there; do this from the DIM prompt by typing DIMTXT, or from the command prompt by typing SETVAR DIMTXT.

To dimension small circles or arcs, type or select DIM DIA for the diameter or DIM RAD for the radius. If the circle is so small that text won't fit in it, AutoCAD gives you a rubber-band line so you can pick a location for the dimensions. For angles, such as the part labelled Heatsink 2, DIM ANG will also let you specify an empty area for the text and extension lines.

At the top of the chassis in Fig. 8, I've used cumulative dimensioning; the 6" takes off where the 3.5" ends. If you'd prefer to have all the dimensions start at the left (or any other specified point), use DIM BASELINE. This will offset the dimension lines so they don't overwrite each other. It takes up a lot more room, but each location gets its own measurement back to a common point.

Don't forget the versatile Polyline, or Pline. It may be cumbersome to edit, but the idea of having line segments of any width forming a continuous line is too good to ignore. At the bottom of the drawing you'll see a widget marked "module". This was drawn as a polyline following the Snap and Grid layout. Then the Fillet Polyline command rounded all the corners in one operation (except one — I didn't Close the polyline, so a break remains where one end joins the other). The Offset command drew the Pline around itself to produce the double-wall effect in one command.

The above commands and tips are only a few of the many zillion that you can find in AutoCAD, but they'll get you started. ■

Techie's Guide to C Programming Part 10

File operations under C look extremely complex. This is exacerbated by there being at least three ways to do everything. In this installment we'll look at sorting out some of the confusion.

STEVE RIMMER

If you're new to C programming... and especially if you've tried similar tasks in BASIC... you'll know that writing programs which involve disk file operations is a bit tricky. Actually, the disk file stuff is dead easy... it's just the way that most programming languages make you access them that can get a bit hairy.

Unfortunately, the disk file operations available to a C programmer are pretty numerous, and it's by no means obvious which functions are intended to be used in which applications. If you've perused your compiler's reference manual, you've probably come away with a head full of file pointers, file numbers, long offsets and relative seeking.

It's almost enough to send one back to BASIC. Almost.

The first thing that's important to realize about file handling in C is that you can ignore at least two thirds of the available facilities offered by your compiler. For reasons we'll get to, there's a lot of redundancy in there. If we start with the remaining file operations, things will start to work a bit more seamlessly.

Handling the Handles

The profusion of file services under C stems from two causes... or possibly three. The first one is historical. Early microcomputer C compilers were not always able to implement higher level file handling, even though the definition of C called for it. As such, they provided oftentimes pretty crude low level, block oriented file functions. Later compilers, wishing to remain compatible with their forebears, maintained some semblance of these functions along with the newer, more useful functions. As such, multiple levels of file functions came to be.

The more prominent cause, however, has to do with the way DOS on the PC likes to handle files. In a sense, it's quite powerful at this, especially in relation to earlier operating systems. C provides us with varying levels of access to this power, depending on what we're up to at the moment.

The simplest form of file access is *sector* access. One saw this sort of thing happen a lot under CP/M, the eight bit precursor to MS-DOS. A disk file is really made up of what are called "allocation blocks", or, in a still simpler sense, disk sectors. As such, using sector based file access, one is able to read or write specific sectors of a file. A sector was one hundred and twenty eight bytes under CP/M... it's of varying size under MS-DOS, but no DOS based C compiler with any pride at all would ever expect its users to work with files this way.

Using sector access, if you wanted to read a specific byte from a file, you would figure out which sector that byte resided in like this

```
sector_number=byte_number/sector_size;
```

and then read that sector into a buffer. Next, you'd figure out how many bytes into the sector buffer the one you wanted was.

```
offset=byte_number % sector_size;
```

The byte you wanted would be

```
the_byte=sector_buffer[offset];
```

As I said, you won't have to do this on a PC.

What C does offer us on a PC... somewhat akin to this but with rather more flexibility... is *block* access. In this access procedure, you really get to deal with DOS as DOS deals with its files. It allows you to read or write from any point in a file, and to deal with blocks of any size. This is often referred to as "low level" file access.

Low level file access is handled by the following functions under C.

open to establish a link to the file in question
read to read in blocks of data
write to write out blocks of data
lseek to position the file pointer
close to close the file

Some of this might not be completely clear just yet... don't worry about it for the moment.

Handling files in this way is great if you want to read and write large blocks of data, because low level file access is fast. For example, this function will save the entire text screen of a PC into a file called SCREEN.TXT. The file will be four thousand bytes long.

```
save_screen()
{
char *p;
int handle;

if((hand-
le=open("SCREEN.TXT",O_CREAT))
!=-1)){
p=MK_FP(0xb800,0);
write(handle,p,4000);
close(handle);
} else puts("Error creating file");
}
```

In this example, the *MK_FP* function is used to synthesize a pointer which points to the base of the screen buffer... don't worry about how this works for the moment. We'll assume that the video card in question is a CGA card and that the text screen happens to be on page zero.

The *open* function returns a number called a *file handle*, or —1 if the file couldn't be created for some reason. The argument O_CREAT tells *open* to create the file in question. In fact, these arguments are quite complex... we'll look at them properly later on in this series.

A file handle is actually a number which serves as an index into a series of file pointers. We'll see what a file pointer is shortly.

The *write* function writes the contents of the screen buffer to the file whose handle is passed to it. The *close* function tidies up the file and *releases* the handle, that is, it severs the link with the file and makes the handle available for future use.

We're actually going to get into this level of file access in greater detail in a coming issue, because it's not all that useful for most of the things you're likely to want to write immediately. Its drawback is that it's great for dealing with large blocks, but quite sloppy if you want to read or write a single byte. You can do it... just read in a block that's only a byte long... but the efficiency of low level file access kind of up and vanishes when you do this.

Streams and Rivers

The other options for file access under C is "high level" file handling, which is the really powerful way to handle files. This allows you to deal with them in the way that most programs want to, that is, on a single byte level. However, high level file access is flexible... you can use both byte by byte access and block access in the same file.

The functions which do high level file access all have the letter "f" in front of them. The equivalents of the low level functions, above, are as follows.

fopen to establish a link to the file in question
fread to read in blocks of data
fwrite to write out blocks of data
fseek to position the file pointer
fclose to close the file

There are also two others we'll look at here.

fputc to write a single byte to the file in question
fgetc to get a single byte from the file in question

In order to deal with a file, we have to start by opening it. This does several things. If the file is to be read, opening it makes sure that it actually exists. If it's to be written to, opening it creates the file. If it's to be appended... its current contents read and possibly altered... opening it makes sure that you're allowed to do this, that is, that the file is not read only.

Opening a file using high level access also establishes a pointer to a structure of the type FILE. The structure itself is put somewhere by the file management routines of C... you will never create FILE variables in your programs, just pointers to them. This is what's actually in a FILE variable.

```
typedef struct {
short    level; /* fill/empty level of buffer */
unsigned    flags; /* File status flags */
char    fd; /* File descriptor */
unsigned char hold; /* Ungetc char if no
buffer */
short    bsize; /* Buffer size */
unsigned char *buffer; /* Data transfer
buffer */
unsigned char *curp; /* Current active
pointer */
unsigned    istemp; /* Temporary file in-
dicator */
short    token; /* Used for validity check-
ing */
} FILE;
```

None of this need mean a thing to you. Not only will you never have to create one of these variable... you'll also never have to use any of the members that a FILE pointer points to. We simply pass these things around, oblivious to what they really do. The high level file routines do all the work.

Here is an example of the use of the *fopen* function. In this case, we are going to open a text file to be read.

```
FILE *fp;

fp=fopen("WOMBAT.TXT","ra");
if(fp==NULL) puts("File not found");
```

Actually, the correct... convoluted... way of writing this would be

```
if((fp=fopen("WOMBAT.TXT","ra"))!=
NULL){
/* do something */
} else puts("File not found");
```

Both versions do the same thing.

The *fopen* function returns a pointer to a FILE structure which C has created behind our backs. If the pointer points to NULL... location zero... the file didn't open for some reason. When *fopen* successfully opens a file, the FILE variable will have its fields filled in by *fopen*, although as we saw, we never deal with them and needn't care what gets put in them.

The first argument to *fopen* is the name of the file. This could be a complete DOS path if we wanted it to be, as in

```
fp=fopen("D:\TEXTFILE\WOM-
BAT.TXT","ra");
```

The second argument is a bit more involved. It tells *fopen* what the file mode will be.

The first character of the argument can be "r" if the file is to be opened for reading. In this case, any attempt to write

to the file would fail. It could be "w", in which case you could write to the file, but not read from it. If *fopen* is asked to open a file for writing, it destroys the existing contents of the file if there's already a file with the name in question on your disk. Finally, the first character could be "a", for appending, in which case you could both read from and write to the file.

The second character can either be "a" or "b". The "b" option is called *binary mode*, and it means that data moves in and out of the file unchanged. The "a" option is often referred to as *cooked mode*. It's especially designed for text applications. It means that carriage returns and line feeds are handled in a way which is convenient and easy to work with under C.

There are more options available for *fopen*, but we'll look at them a little later on.

Having established a pointer to a file structure with *fopen*, we can proceed to use the file. This code would read in the contents of a text file and display them on the screen.

```
while((putchar(fgetc(fp))!=EOF);
```

You'll want to look at this carefully for a moment. What it's really saying is this.

```
intc=0;

while(c!=EOF){
c=fgetc(fp);
putchar(c);
}
```

Left to its own devices, the *fgetc* function simply keeps returning bytes from the opened file until the file has all been read, at which time it returns the constant EOF.

It's important to understand that *fgetc* returns an *int*, even though it's really only getting *chars* from the file. The upper byte of the *int* will usually be empty. However, when the end of the file is reached, the *int* will contain —1, that is, 0xffff. This is how we differentiate between an EOF and a legitimate byte which contains 0xff.

This can cause a lot of problems if you aren't careful. For example, you might look at the above bit of code without thinking and decide that the variable "c" really only needs to be a *char*. If you do this, *c* will never equal EOF, since EOF is a sixteen bit value and *c* can only hold eight, being a *char*. As such, this code will never know when it's reached the end of the file, and it will loop forever.

When we're done with a file, we must close it, as before. This is done by saying

```
fclose(fp);
```

Closing a file which has been opened for high level file access does a number of things. It frees up the FILE structure for future use. It also *flushes* DOS's internal file buffers.

Flushing a file buffer really only matters if you've been writing to the file in question. However, it illustrates how high level file access really works. If you write one byte to a file with *fputc*, your program does not send that byte directly to the disk. It would be extremely inefficient to have to wake up the disk drive, seek around on the disk for a while, find the appropriate sector, read it in, place the byte in question and write it back out every time you call *fputc*.

Instead, the byte is added to a buffer. When the buffer gets full, a whole block of data is written to the disk. The buffer is then emptied, and subsequent calls to *fputc* continue to flow into the buffer.

If you close the file, any unwritten bytes in the buffer are written out to the disk. If you fail to do this, everything since the last automatic block write will be lost.

In a large program, it's important to remember to close your files when you're done with them. This flushes the file buffers in question. It also frees up FILE structures. If you try to open too many files, *fopen* will start returning NULL pointers, even though the files you've asked to be opened are valid and should present no problems.

The Circular File

We'll be continuing to look at file access under C next month. However, you might want to have a look at this practical application of the file functions we've seen today. This program converts WordStar files to plain text files using high level file functions. Actually, the only difference between a WordStar file and a text file is that the former has some of its characters stored with their high bits set. If we AND all the characters in the file with 0x7f... recall the discussion of bit manipulation from last month... the result will be clean text.

```
main(argc,argv)
intargc;
char*argv[];
{
FILE*source,*dest;
intc;

if((source=fopen(argv[1],"rb"))!=NULL)
{
if((dest=fopen(argv[2],"wb"))!=NULL){
while((c=fgetc(source))!=EOF)
fputc(c&0x7f);
fclose(dest);
}else printf("Can't open %s as destination\n",argv[2]);
fclose(source);
}else printf("Can't open %s as source\n",argv[1]);
}
```

This program uses command line arguments, which we haven't formally looked at yet. However, you can probably see how they work. Assuming that it was called UNWS.C... leaving you with UNWS.EXE after it is compiled... you would convert WOMBAT.WS into WOMBAT.TXT like this.

```
UNWS WOMBAT.WS WOMBAT.TXT
```

In practice, we could make this into a better WordStar converter with a few more lines of code, but this serves to illustrate just how flexible high level file access can be.

Next month we'll see some of the other things it can balance on its nose. ■

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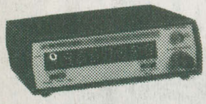

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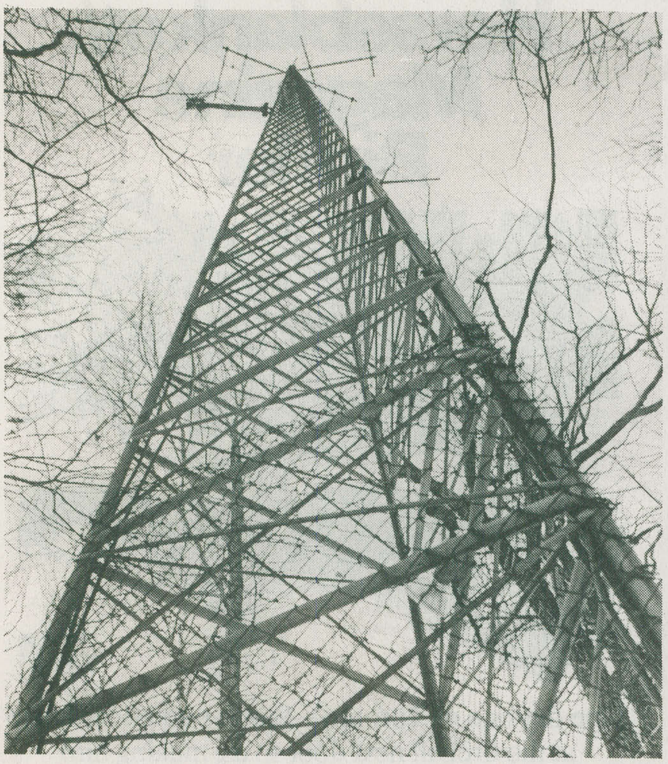

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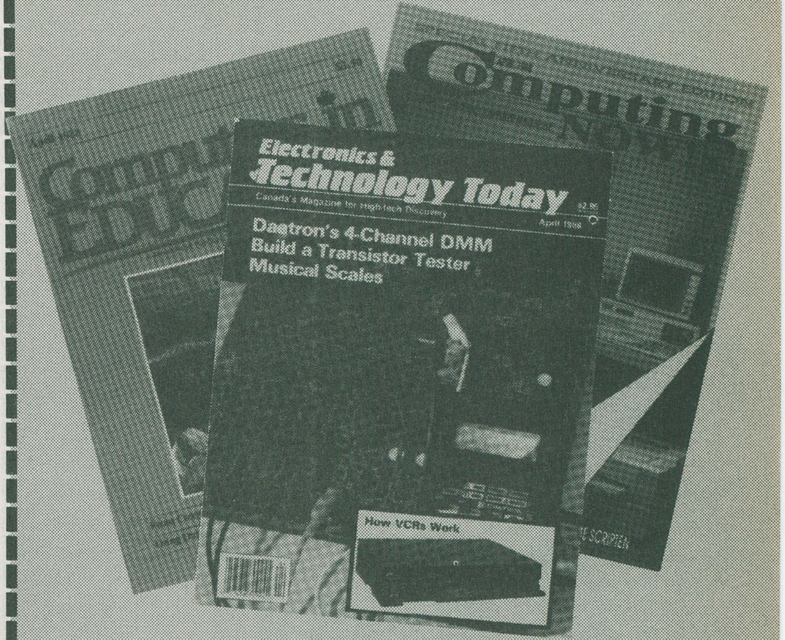

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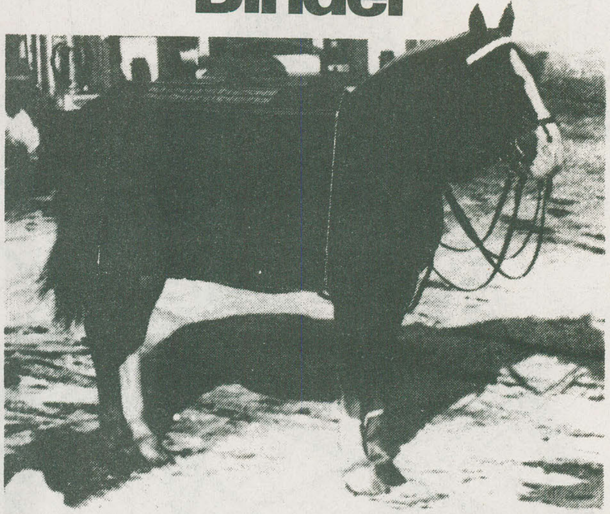

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Fuse Tester

A simple method of checking the condition of your fuses.

CHRIS BOWES

Although a simple fuse tester can be made very easily by connecting a LED, through a suitable dropping resistor, to a battery via the fuse under test, the output does need a little bit of understanding (to work out that an illuminated LED means a working fuse). In order to both make the understanding of the result of the test easier and to make the project a little more interesting this circuit has been designed to produce an unambiguous result by using two LEDs, one of which signifies a good fuse while the other signifies a blown fuse.

How it Works

The Fuse Tester described here makes use of the operation of two simple amplifiers (op amps) used as comparators. All op amps have an inverting and a non-inverting input. These are identified on circuit diagrams with a minus sign and a plus sign.

Normally op amps are used with a feedback resistor between the output and the amplifiers inverting input. This is used to set the gain of the amplifier. If this "feedback" resistor is omitted then the amplifier has basically an infinite gain, limited only by the voltages of the power supply available to it.

The amplifier then amplifies the difference between the voltages available at the inverting and non-inverting inputs by a factor determined by the value of the feedback resistor. Because the infinite gain of an op amp used without a feedback resistor, the output voltage swings from the most negative voltage available to the most positive voltage available depending upon whether the inverting input or the non-inverting input is at the higher voltage. In this project the voltage of the non-inverting input of both op amps is set to half the battery voltage, so that the voltage presented to the inverting input is used to control the operation of the op amp.

Circuit Description

The circuit diagram for the Fuse Tester is shown in Fig.1. ICa and ICb are each one half of a CMOS operational amplifier type CA3420.

This integrated circuit contains two individual op amps which are pin compatible with other dual op amp integrated circuits. These particular op amps are, however, designed to work from a single power supply, such as a 9V battery. Resistors R1 and R2 are used to set the input voltage to the non- inverting input of IC1a (pin 2). Because they are of equal value the voltage available at pin 2 is approximately 4.5V (50 percent of the battery voltage).

Similarly resistors R5 and R6 are used to set the voltage at the non-inverting input of IC1b (pin 7) to 4.5V.

IC1a is used as a comparator to detect whether the voltage at its inverting input (pin 1) is at a higher or lower voltage than the reference voltage at the non-inverting input. Resistor R3 is used as a pull up resistor which sets the voltage at pin 1 of IC1a to the battery supply voltage when the fuse under test is an "open circuit".

In this condition the voltage at the inverting input is greater than the voltage available at the non-inverting input. This causes the output voltage of IC1a to be forced to 0V.

If the fuse under test is in good condition it presents a "short circuit", which causes the voltage available at pin 1 of IC1a to be "pulled down" to 0V. In this condition the voltage at the inverting input is less than the voltage at the non-inverting input and the output of IC1a is forced to the battery voltage.

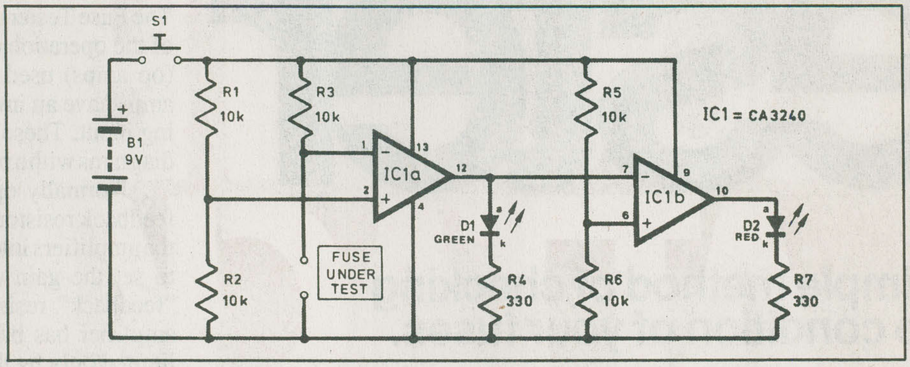


Fig. 1. Complete circuit diagram for the fuse tester.

This allows a current to flow through D1, and its associated series resistor R4, and D1 glows. Resistor R4 is included in this circuit to limit the current flowing through D1 to its safe value of approximately 10mA.

The second stage, IC1b acts as an inverter in that if the output from IC1a is at 0V then the voltage at the inverting input of IC1b (pin 6) is less than the voltage at the non-inverting input (pin 7). This causes the output of IC1b to rise to the battery voltage causing a current to flow through D2 in the same way as does the current through D1.

If the output from IC1a is at the battery voltage this causes the input voltage at the inverting input of IC1b to be greater than the voltage at the non-inverting input. This causes the output voltage to be at 0V and no current can flow through D2. The effect of this arrangement is that D1 is illuminated when the fuse under test is sound and D2 is illuminated when the fuse under test is blown.

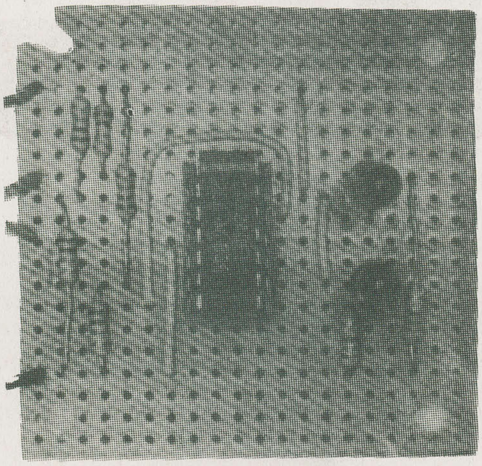
Switch S1 is a push-to-make type which is incorporated in the circuit so that the circuit only becomes active when S1 is operated. This reduces battery wear by making sure that the battery is only used when a fuse is actively being tested.

Construction

The Fuse Tester is constructed on a piece of stripboard and the component layout and breaks required in the underside copper tracks is shown in Fig. 2 and the photographs. You will probably find it useful to look at these while you are constructing the project.

The first stage of construction is to cut a piece of stripboard 20 holes by 20 strips. The four mounting holes shown in Fig. 2 should be drilled in the board using a 4mm drill bit.

The next task is to carefully make the track breaks in the area where the integrated circuit is to be mounted, as shown in Fig. 2. These can be made by using a stripboard cutter or alternatively a suitable size drill bit may be used. It is very important that these breaks in the tracks are made completely and that you ensure that there is not even the most minute trace of conductive material left to bridge the sections between the broken tracks.



Completed circuit board showing the four insulated wire links.

Once the board has been prepared then the components may be inserted and soldered into position. The operation of the circuit is not affected by the order in which the components are installed on the circuit board but you will find it easier to handle the board if the components are inserted in ascending size order.

The first components to be inserted are the four link wires shown in Fig. 2. These links are made with insulated wire, which you will need to "tin", pre-solder, before installing. If you are using stranded wire you should carefully twist the exposed strands between your finger and thumb so as to make a neat compact end to the stripped wire before "tinning".

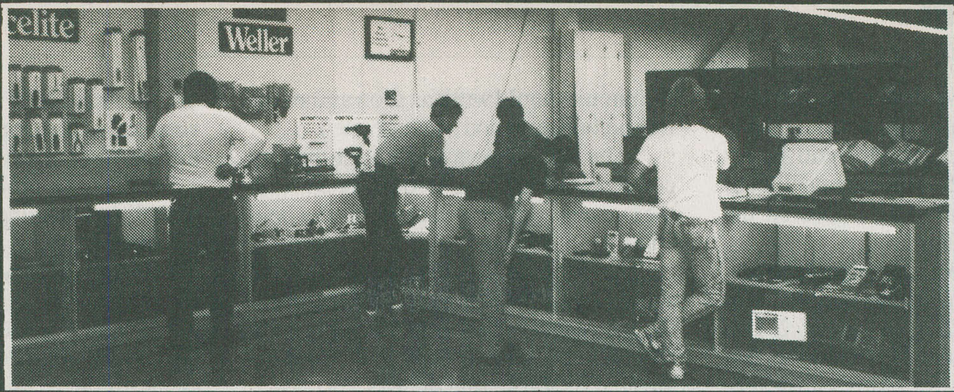
To install the wire link it is necessary to count up or down along the edge of the board until you find the correct strip and then count along that strip until you find the correct hole where the link should be inserted as shown in Fig. 2. Once you have found the correct place to insert the wire link then the prepared end should be passed through the appropriate hole on the board, the board turned over and the link soldered into place.

The next components in ascending order of size are the resistors. Insertion of these components is made easier if the leads are first bent at 90 degrees with a small pair of long-nosed pliers, at the correct places where they need to pass through the holes in the board as indicated in Fig. 2. It is important when soldering any components onto a stripboard that the soldering iron should be left in contact with the component wire *and* copper track long enough for the applied solder to flow and make a good joint between the component and the connecting strip.

Now insert the IC holder and LEDs in the position shown. CAre should be taken with the IC socket to make sure that the notch on the holder points towards the top of the board as shown in Fig. 2. This also applies to the LEDs. You will find that the LED carries a flat on the otherwise circular base of the components; this flat is nearest to the cathode (k) connection, see Fig. 2.

The final stage before inserting the integrated circuit is to connect the battery connections and the wires leading to the fuse carrier. The easiest way to connect the battery to the circuit board is to use a suitable battery connecting clip.

The red (positive) wire from the bat-



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tery clip should go to one of the two connecting tags on the push-to-make switch (S1). Another piece of wire will be required to go from the other connection of S1 to the point marked B1 +Ve on the board, as shown in Fig. 2.

The two connections to the fuse carrier are made with two wires terminated at the points marked "To fuse" on Fig. 2. You will find it easier to make the connection to the fuse carrier "brackets" at a later stage if these wires are each fitted with a small solder tag prior to the other ends being connected to the board.

Testing

Before connecting the battery and installing the board in a suitable case it is advisable to check the underside of the board to ensure that there are no solder blobs shorting out adjacent tracks or breaks in the track where you do not wish them to occur. It is also advisable to check that IC1 and the two LEDs are inserted into the board with the correct orientation.

Assuming that all is correct here than the circuit should work as soon as the battery is connected and S1 is operated.

The test sequence, with the battery correctly installed, is to operate S1 with the two wires going to the fuse carrier held apart.

As soon as S1 is operated then D2 should light. When the two wires going to the fuse carrier are shorted together with S1 operated than D2 should be extinguished and D1 should light.

If the circuit does not operated as described above then it will be necessary to start fault finding. It is really impossible to fault find on this circuit without access to a d.c. voltmeter or alternatively a multimeter.

A simple meter will, however, be suitable for all the fault finding processes necessary for this circuit.

Fault Finding

The first stage in fault finding is to repeat the visual check described earlier in the testing section. If this visual inspection produces no signs of anything wrong with the construction of the circuit then it is advisable to check that the battery connections are the correct way round.

This will probably be most easily done by connecting the voltmeter across the strips carrying the positive and negative battery supply along the stripboard and pressing S1. If all is well with the battery and the connections then the voltage read on the voltmeter should be the same as that produced by the battery.

If no voltage, or a very low voltage, is measured across these rails when S1 is pressed than the positive probe of the voltmeter should be connected to the contact on S1 which is connected to the battery. The battery voltage here should be the same as that produced by the battery irrespective of whether S1 is depressed or not.

If the battery voltage is present when S1 is not operated but disappears when S1 is pressed then this indicates that there is a short circuit on the stripboard and this should be examined carefully, especially the area around IC1.

If this inspection produces no enlightenment then IC1a should be removed from its socket and the test repeated. If the removal of IC1 cures the problem then it would indicate that this component is faulty and it should be replaced.

Comparator Tests

Following on the fault finding procedure, check that the comparator formed by IC1a and its associated components is functioning correctly. If S1 is operated with an open circuit across the fuse carrier wires then the output from IC1a should be 0V.

When the two wires going to the fuse carrier are shorted out and S1 is operated then a voltage, approaching the battery voltage, should be measurable at pin 12 of IC1a. If this does not occur then the voltages at pins 1, 2, 3, 4 and 13 of IC1a should be checked.

The voltages at pins 1, 2 and 13 should be measured with the negative connection of the voltmeter connected to any contact of the 0V track. The voltage at pin 13 should be at the battery voltage for as long as S1 is operated. If this does not happen then the link between pin 13 and the strip carrying the Batt+ connection should be checked.

Now check the voltage between the positive battery input to S1 and pin 4 of IC1a. Again the battery voltage should be measurable when S1 is operated.

If either of these checks produced no voltage reading at all then it is necessary to check back along the connections to the

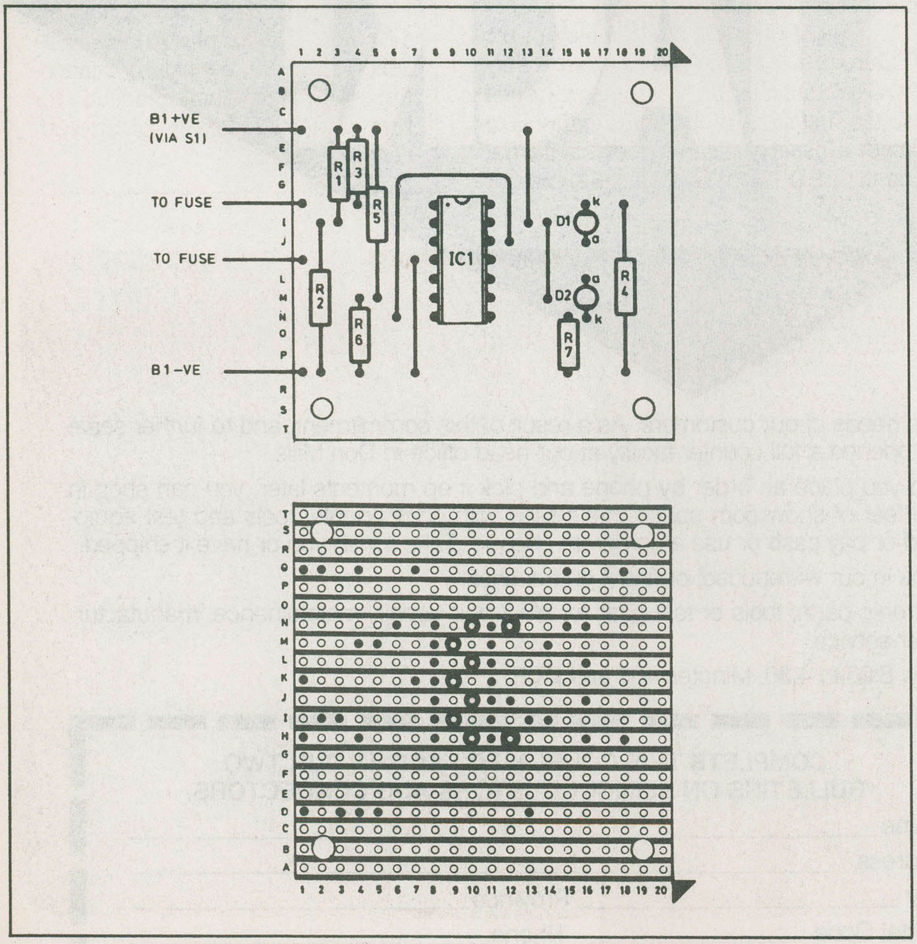


Fig. 2. Stripboard components layout and details of the breaks required in the underside copper tracks.

stripboard, battery and S1 until you find the place where the battery voltage appears. The fault will be found to be immediately after that point.

With the voltmeter's negative probe connected to a suitable 0V point, the voltages at pins 1 and 2 of IC1a should be checked. The voltage at pin 2 should be approximately 4.5V. The precise voltage measurable at this point is not *critical* as long as it is somewhere in the range between 3V and 6V.

If this voltage is not measurable or is considerably higher or lower than the range given then the potential divider formed by resistors R1 and R2 is the most likely cause of the problem. The voltage at the positive end of resistor R1 should be the battery voltage (when switch S1 is pressed) and 0V at the negative end of R2.

The voltage at the junction of resistors R1 and R2 should be approximately 4.5V and this voltage is connected, via the appropriate line on the stripboard, to pin 2 of IC1. If the voltage at the junction of R1 and R2 is considerably higher than 4.5V then it is most likely that the connection between R1 and R2 or that the connection of the 0V end or R2 are not properly made.

Similarly if the voltage at the junction of R1 and R2 is considerably lower than 4.5V then either the connection between R1 and R2 is faulty or the positive connection of resistor R1 to the positive power supply rail is faulty. In all of these cases it is advisable to check the quality of the joints, and if necessary, remelt the joints by applying the soldering iron once more at that point.

Fuse Carrier

The voltage at pin 1 at IC1a is determined by the state of the two wires which connect to the fuse carrier. When two wires going to the fuse carrier are connected together pin 1 of IC1a is effectively connected to 0V. When the two wires going to the fuse carrier are *not* connected together then the current from the positive battery rail flows through resistor R3 to pin 1, causing the voltage at this point to be at battery voltage.

The voltage at pin 1 should be monitored under both of these conditions with S1 pressed. If the battery voltage at pin 1 remains at 0V, irrespective of whether the fuse carrier wires are shorted out or not, then the fault is most likely to lie with the connections to resistor R3. If the battery voltage is always present at pin 1, irrespective of the connection or disconnection of the two wires going to the fuse carrier then the connections to the fuse carrier, via the wires and the appropriate strips on the stripboard should be checked carefully.

If all of these tests give the correct result then the output at pin 12 of the IC should be determined by the voltage measured at pin 1 of IC1a. If pin 1 is at 0V when S1 is pressed then there should be battery voltage present at pin 12. If pin 1 is at battery voltage when S1 is pressed then the output voltage at pin 12 of IC1a should be approximately 0V.

If this does not occur then the connections to pins 12 and 6 of the IC and in the vicinity of D1 and resistor R4 should be carefully checked to ensure that there is no inadvertent short of the output of IC1a to 0V. If no short circuit is found then IC1a must be suspected of being faulty and should be replaced.

If an output voltage approaching the battery voltage is produced at pin 12 of IC1 but D1 does not light than the next stage is to check through the connections from pin 1 of IC1 to the anode of D1, from the cathode of D1 to resistor R4, and from R4 to the 0V line of the stripboard should be checked for continuity.

One of the most likely causes of the failure of D1 to illuminate is that it may well be connected in the wrong way round so the first stage of the fault finding is to make a visual check to ensure that the flat on the LED's base is adjacent to resistor R4. If all is found to be correct than an LED which is known to be working can be connected across D1, taking care to ensure correct polarity is maintained. If the substituted LED works then D1 should be removed and replaced.

If D1 illuminates correctly and D2

PARTS LIST

Resistors

R1,3,5,6 .... 10k
R4,7 .... 330 ohms
All 0.25W 5% carbon

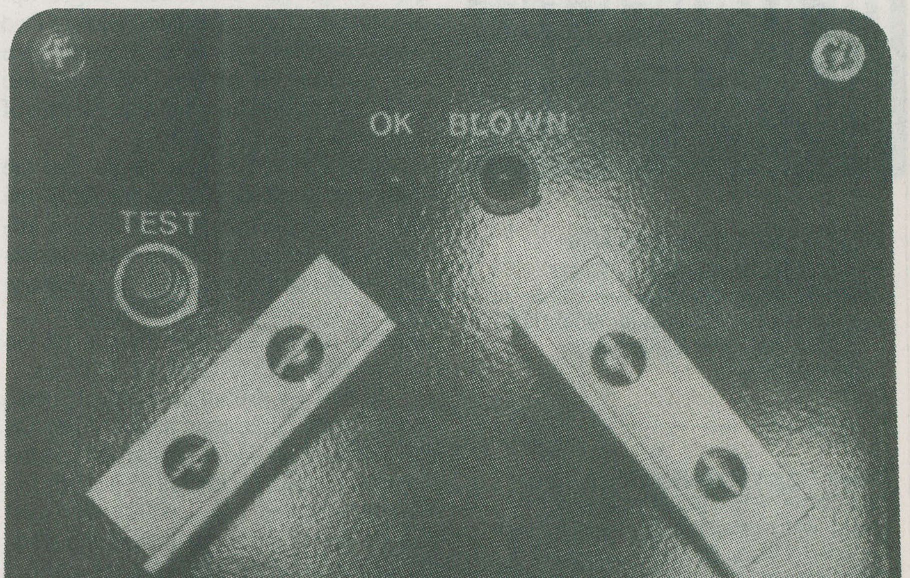
Semiconductors

D1 .... green LED
D2 .... red LED
IC1 CA3240E Dual CMOS op amp

Miscellaneous

S1 Single-pole push-to-make switch
B1 .... 9V battery

Stripboard, 20 holes x 20 strips; 14-pin IC socket; plastic case; self-adhesive stand-offs; battery connector; solder tags; aluminum angle for fuse carrier (see text); solder; connecting wire, etc.



Completed Fuse Tester showing the LEDs, push-to-test switch and the fuse carriers made out of aluminum angle.

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does not then the circuitry associated with IC1b should be checked in the same way as details for IC1a. The positive supply connection to IC1b is a separate one to that connected to IC1a so the voltage between 0V and pin 9 should be checked. When S1 is pressed the voltage measured between pins 4 and 9 of IC1b should be the battery voltage.

The second difference to check is that the voltage at the inverting input (pin 6) of IC1b is the same as that at pin 12 of IC1a. This should be checked with a voltmeter and if the two voltages do not correspond then the connections between these pins should be checked. Apart from these differences IC1b can be fault found in the same way as IC1a.

Case

The fuse tester is designed to be mounted inside a case and for this reason the LEDs have been positioned so that the board can be mounted on the back of the case lid, with the LEDs protruding through the front of the case. The fuse carrier has been designed to be made from two small pieces of aluminum angle strip drilled in such a way that they may be mounted on the front of the case as shown in the photograph. The two strips are mounted at an angle to each other, so that a number of different lengths of fuse may be tested.

The first task is to cut two pieces of one centimetre aluminum angle approximately three centimetres long. Two holes sufficiently large to accommodate the mounting bolts you intend to use should be drilled into one side of each of the pieces of aluminum angle.

Place the aluminum angle and the push to test switch (S1) in the lid of the case, taking care to ensure that there is sufficient space underneath the lid to accommodate the stripboard. Once appropriate places have been determined for the components these should be marked on the case and the holes of correct size drilled.

Switch S1 should be relatively close to one of the aluminum angles. This has been deliberately done so that one handed operation may be achieved by holding the fuse against the fuse carriers with two fingers and using the thumb of the same hand to operated the push-to-test switch.

Once the appropriate holes have been marked and drilled the case may be lettered with rub down lettering which may then be protected by the application of several layers of clear varnish. Once the varnish is dry carefully mount the fuse carriers with nuts and bolts, ensuring that there is sufficient clearance between the end of the bolt and board when mounted underneath the case.

The two LED clips should now be positioned in their appropriate holes in the case. The stripboard should be mounted on the underside of the lid in such a way that the two LEDs fit into the two clips.

Ideally the board should be held in place by means of self- adhesive standoffs. These should be placed, from the component side, in the holes drilled in the stripboard to accommodate them. The protective backing should then be peeled off the sticky pads and the board carefully offered into place, ensuring the LEDs fit through the holes in the case front.

When the position of the component board has been accurately determined then the sticky pads should be pushed firmly onto the surface of the case so that they stick firmly on the case lid. Once the pads are in place then the board should be carefully removed and the connections made to the two fuse carriers.

If solder tags have become attached to the end of the two wires which connected to the fuse carrier then connection becomes simply a matter of placing the solder tag of one of the wires underneath one of the two bolts holding each of the two fuse carriers. Switch S1 can also be installed and the wire connections made to it, at this stage.

The final stage of fitting the project into its case is simply a matter of placing the rings which secure each of the LEDs in to its clip, around each of the two LEDs and offering the stripboard into its position on the already attached standoffs. Care should be taken to ensure that the LEDs fit neatly through the two clips already installed in the case before sliding the securing rings around the base of the clip to lock them into position.

The battery can then be attached to the battery clip and the circuit checked for correct operation, as described above. This check should, of course, be carried out before fitting the back of the case onto the lid and securing the lid to the case with the four screws.

In Use

The Fuse Tester is very simple to use. All that is necessary to do is to place the suspect fuse so that it makes good contact with the two strips of aluminum angle, which form the fuse carrier, and press the test button (S1). One of the two LEDs should illuminate, indicating whether the fuse is sound or not. ■

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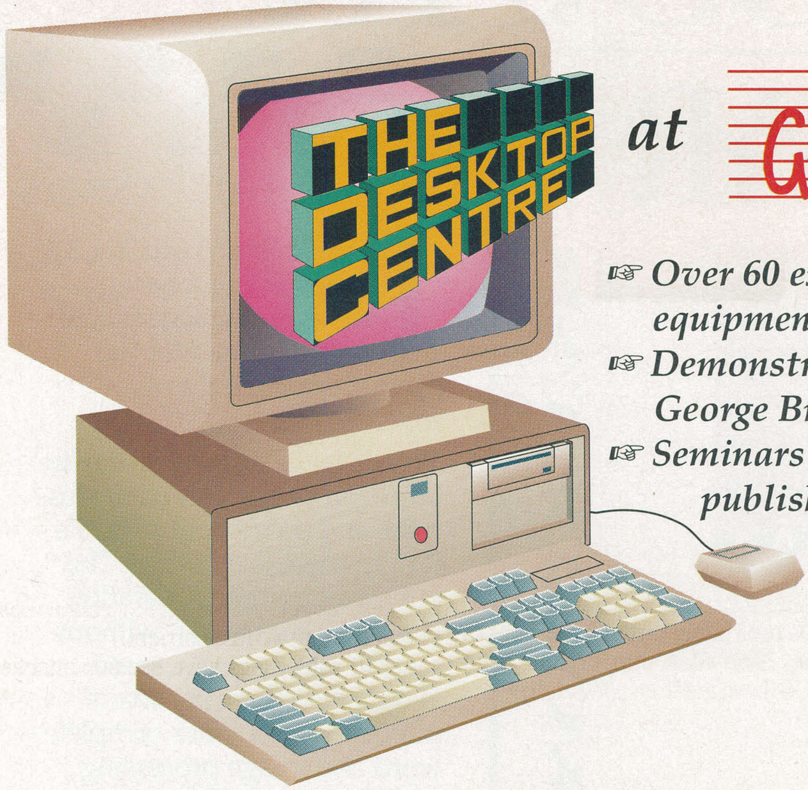

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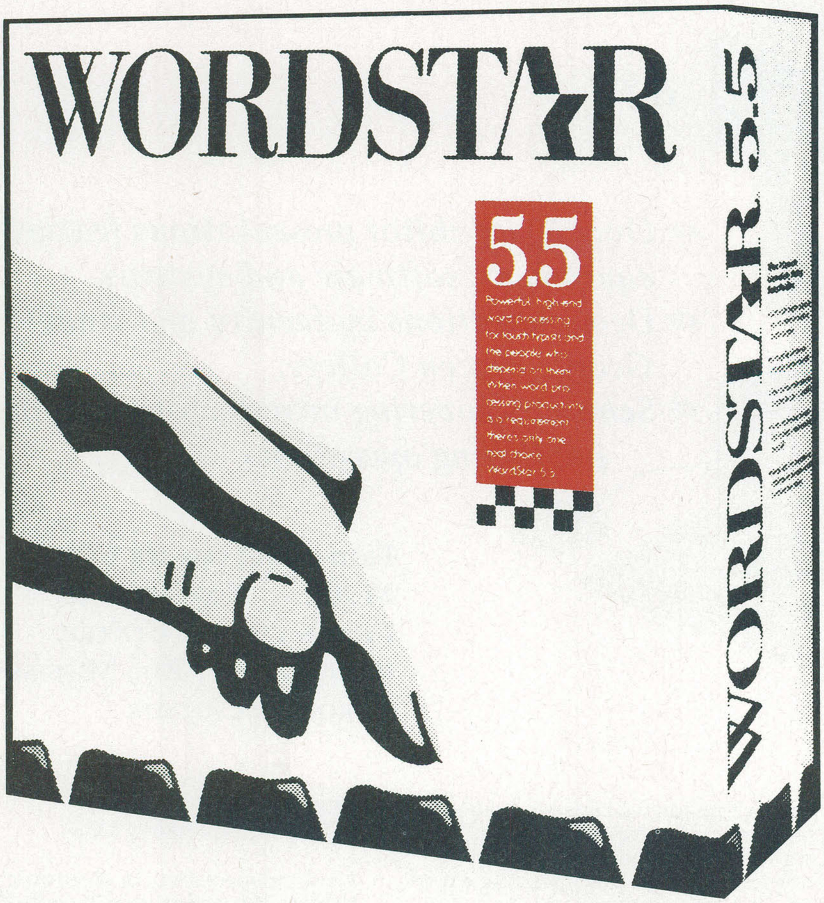

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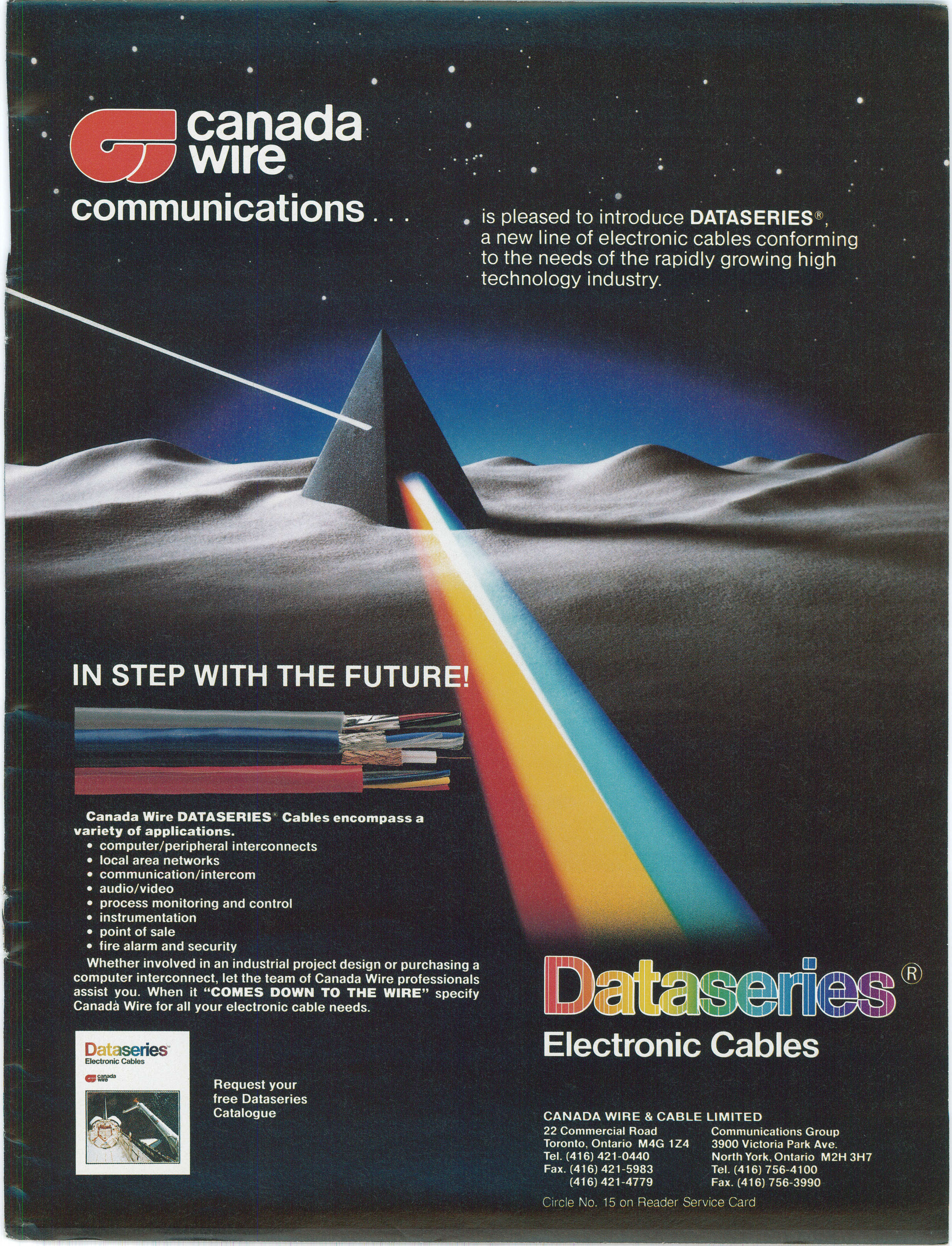
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